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The Building of TVA

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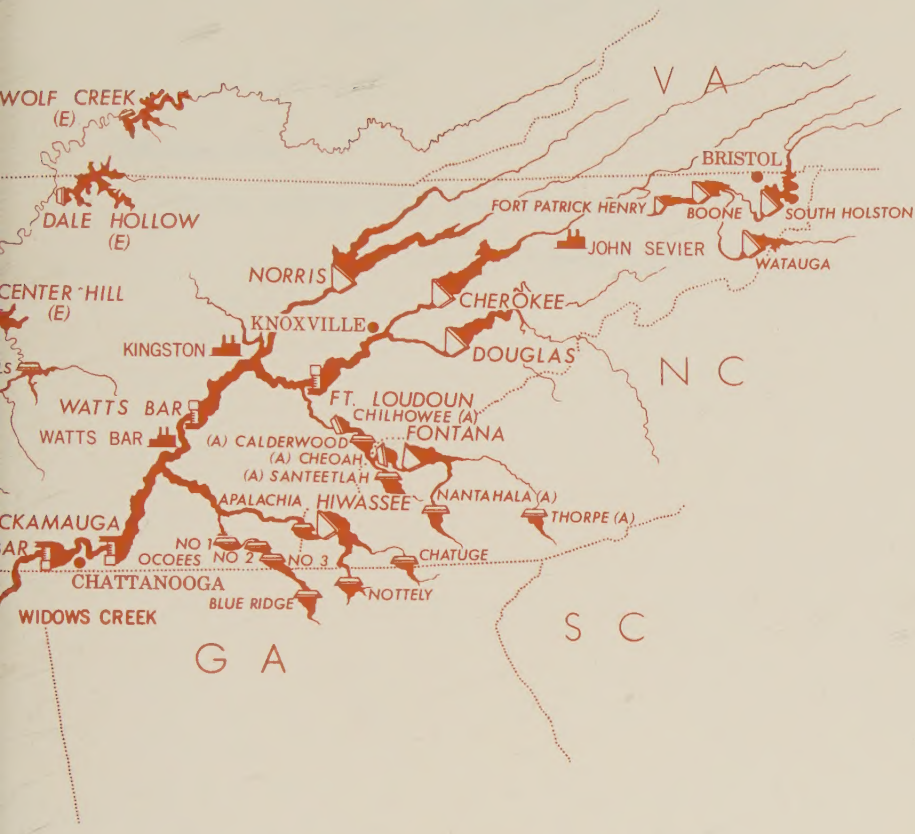

TVA

AN ILLUSTRATED HISTORY

by JOHN H. KYLE

Louisiana State University Press: BATON ROUGE

First Edition
© 1958 by Louisiana State University Press
Baton Rouge, Louisiana

Printed in the U. S. A. by The Meriden Gravure Company
Composition by The Stinehour Press, Lunenburg, Vermont
Designed by Pauline Manning

Library of Congress Catalog Card Number 58: 7554

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DEDICATED

to the people of TVA, past and present . . .

THIS IS THEIR BOOK

PREFACE

After twenty-five years, the idea of the Tennessee Valley Authority has come to be recognized generally as a successful one. The purposes for which it was established have been more than fulfilled, for if it can truly be said of any river, it can be said that the Tennessee has been harnessed and made to work for the good of man. From a sullen, recalcitrant stream that turned its power against man as often as it served him, the Tennessee has been transformed into a series of stilled lakes spilling quietly from one to another, spending its great energy in the revitalization of the valley through which it flows.

A plethora of books, pamphlets, and articles have told us what TVA has accomplished in flood control, navigation improvement, low-cost power production, agriculture, forestry, city and regional planning, and even in the science of government. David Lilienthal's *TVA, Democracy on the March* and Gordon Clapp's *The TVA: An Approach to the Development of a Region*, to name but two books, have provided us with excellent over-all perspectives of TVA's aims and achievements. This book, for the first time, traces the history of the design and construction of TVA's "physical plant"—the dams, buildings, bridges, and steam plants on which all of its operations rest. While they are preliminary to TVA's principal activities and purposes, they also represent architectural and engineering triumphs deserving in themselves an important place in the history of American building.

Very early in the development of TVA it became apparent that these projects represented something different in the field of industrial architecture, something new and refreshing. Dams, however large or small, are always fascinating, but in 1936 Norris Dam, TVA's first, attracted attention out of proportion to its importance in flood control and power generation. Its forcefulness and simplicity held an extraordinary appeal for architects, engineers, and laymen alike. Critics uninterested in politics waxed enthusiastic about it; artists came to portray its sculptural quality; photographers came to study its lights and shadows, its textures and planes.

Norris was followed soon by other dams, and each new one proved again that the design level established at Norris was to be maintained, that TVA had an architectural and engineering program comparable

to its high aims in planning and redevelopment. In 1939 a leading professional magazine, *The Architectural Forum*, gave TVA architecture the better part of an entire issue. In 1941 the Museum of Modern Art, in New York, held an exhibit of this architecture, displaying many of the photographs used in this book. In 1943, at the height of World War II, Julian Huxley published in England a book entitled *TVA: Adventure in Planning*, in which a chapter was given to architecture and design.

After the war, TVA launched into another building phase: steam plants. Despite the great difference between thermoelectric and hydroelectric plants, TVA's designers managed to give the same high degree of design excellence to the steam plants that earlier they had given the dams. In 1954, another leading professional magazine, *Progressive Architecture*, bestowed a Design Award on TVA's latest steam plant, Gallatin.

I would hesitate to say, as others have said, that these structures symbolize the spirit of democracy or even the spirit of TVA, for I do not think that it is architecture's function to symbolize in this way. But I do think that the design success of these dams, bridges, steam plants, and other structures is owing in large measure to the political and administrative organization of TVA. The members of the first Board of Directors—Arthur E. Morgan, Harcourt A. Morgan, and David Lilienthal—were perhaps fortunate in their selection of engineers and architects, but more important is the fact that they were too wise (and too busy) to interfere in the work of these designers. As a result, there developed an atmosphere of freedom and experimentation in which the best work of these men could be produced. They were not subjected to political pressures, and their only limitations were time, money, and their own abilities. There also emerged a unique spirit of co-operation among the various divisions of TVA that maximized the value of contributions from each division—a spirit that few organizations, public or private, have ever experienced.

No small part of TVA's successful building program must be attributed to the fact that TVA mobilized and directed its own construction force. As a result, there was continual flow of ideas and information back and forth at every level—from the drafting rooms to the tool sheds—for the same spirit that permeated the architectural and engineering divisions of TVA was felt by the truck drivers and the work gangs, by the foremen and the timekeepers. Without this spirit, it is

doubtful whether there would have been a TVA as we see it in this book.

Facts and Figures

Although work still continues on many of these projects in 1958, and will for some time to come, it was necessary for comparative purposes to adopt a standardized set of figures for the dams and the steam plants. Many of the figures for capacities and costs are estimates made in 1954 and 1955, but except for increases due to the inflationary trend, the estimates will undoubtedly parallel actual costs rather closely. Data for the dams were taken entirely from *Engineering Data: TVA Water Control Projects*, Technical Monograph No. 55, Vol. 1 (Knoxville, 1954); comparable figures for the steam plants were taken from *Engineering Data: TVA Steam Plants*, Technical Monograph No. 55, Vol. 2 (Knoxville, 1955). Both volumes were prepared by TVA's Divisions of Engineering and Construction.

Acknowledgments

The size and co-operative character of TVA make it impossible to list the names of all who played important roles in the design and execution of the structures shown in this book. Aside from the prohibitive length of such a list—even if it could be compiled—it is traditional at TVA that individuals not be singled out for personal credit. I will try to observe this tradition. However, I am compelled to acknowledge those who were helpful to me in the research and writing of this book. At the same time, I must claim full responsibility for whatever errors of fact or judgment that the reader discovers herein, for all decisions in regard to materials used, projects discussed, and comments about them were finally mine alone. At no time did any member of TVA attempt to alter the character of this book or temper a critical statement about TVA.

It was in conversation with Harry B. Tour, Head Architect of TVA, that the idea of such a book first emerged, in 1954, when I was Associate Editor of *Progressive Architecture*. And it was he who has been my principal contact and source of materials throughout my research

and writing. He and Paul L. Evans, Director of Information, together supplied me with facts, data, and illustrative materials that constitute the warp on which the chapters that follow are woven. All of the photographs used are from the files of TVA and were made by TVA photographers: Charles Krutch, R. W. Hickle, E. E. Neukom, Emil Sienknecht, Granville Hunt, A. L. Pitts, G. L. Bracy, J. L. Shadden, and Billy Glenn. To Billy Glenn I acknowledge a special debt of gratitude for the patient effort that he put into the making of all final prints of these photographs before going to press.

I wish also to express my thanks to others at TVA who read the various versions of my manuscript and who were so helpful in their comments and corrections: Harry Wiersema, Jack W. Hind, and John C. Voorhees—Division of Engineering; Gilbert W. Stewart and Maurice Henle—Office of Information. On two occasions I was escorted to several of the projects near Knoxville, once by Robert F. Campbell, and again by Robert T. Case, both of the Division of Design. Their instruction during those trips has been extremely helpful.

Despite the tradition of anonymity at TVA, it would be unfair not to acknowledge the artists who designed and executed the handsome murals in the various visitors' lobbies shown here: Fort Loudoun Dam, Robert L. Birdwell, TVA staff artist, and Kermit Ewing, University of Tennessee Department of Fine Arts; Johnsonville Steam Plant, Kermit Ewing and Joseph Cox, North Carolina State University; Kingston Steam Plant, Robert L. Birdwell.

No discussion of the design of TVA would be complete without a mention of Roland A. Wank. His work in design and planning during TVA's first ten years is acknowledged by many at TVA to be largely responsible for the high aesthetic standard set in that period, a standard that has been so well maintained by his successors in the Division of Design: Rudolph Mock and Harry Tour.

The plan drawings of Johnsonville Steam Plant appear here through the courtesy of Elmer A. Bennett and *Progressive Architecture*; those of Wheeler Dam and Pickwick Landing Dam through the courtesy of *The Architectural Forum*.

During the last several months of writing I enjoyed the close association of Pauline Manning, Art Editor in The Johns Hopkins Press and designer of this book for Louisiana State University Press. She is responsible not only for the presentation of illustrations and text but also for many valuable editorial suggestions.

Finally, may I gratefully acknowledge the inspiration and encouragement that I received from my wife, Jean Kyle, and my daughter, Patty Kyle. Without their patient help, this volume might never have been completed.

BALTIMORE, MARYLAND
MAY 18, 1958

John H. Kyle

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The Building of TVA

Wilson Dam was built at Muscle Shoals between 1918 and 1925.

The Tennessee

CHAPTER I

To many people the world over, the Tennessee Valley Authority represents the highest achievement of American democracy. Few products of this nation hold as much promise for them as does this example of man's conquest of nature. Many countries that have no need or desire for skyscrapers, H-bombs, or space satellites have river valleys in need of TVA-type development. Experts from virtually every country in the world have made special trips to the Tennessee Valley to see the dams, the reforested hills, the revitalized land, and the thousands of acres of stilled water. Many countries wanting experts in river valley development have borrowed them from America, not a few from TVA itself—economists, engineers, planners, architects, and agricultural advisers. Today, river valley development programs are under way in dozens of countries around the globe: India, Afghanistan, Colombia, Mexico, Jordan, even Red China—to name only a few. In other countries, plans and surveys are being made for future projects. Strangely enough, just about the only country not hopefully contemplating another TVA is America.

While Americans created and executed the idea of TVA, we have never been able to give it our complete acceptance. One large group of us looks upon TVA as a triumph of co-operation made possible by a government genuinely of the people, by the people, and for the people; another group—smaller but perhaps more vocal—sees TVA as a dagger at the heart of capitalism, free enterprise, and the cherished concept of rugged individualism. The ideas of both groups are deeply rooted in the American tradition, and have checked and balanced one another advantageously in the past. But in this instance they clash head-on to no good purpose. The "free enterprise" group, though constituting only a small minority as far as the TVA question is concerned, has succeeded to a certain extent in stigmatizing TVA in the public eye. Spending millions of dollars every year, these "rugged individuals" (large private power corporations) hammer away in their endeavor to equate TVA with public power, public power with socialism, and socialism with un-Americanism. The ominous phrase "creeping socialism" is their war cry.

Yet, this whole line of argument falls because of a badly mistaken

premise. TVA is *not* a public power program. Electric power is part of TVA, even a very important part, but to suggest that it is TVA's principal concern is to distort and misrepresent the real purpose of TVA. Essentially TVA is a development agency for an area of America three-fourths the size of England. Its first responsibility in operating its dams and reservoirs is flood control and navigation improvement. The generation and sale of power are subordinate to these on its schedule of multiple purposes. In addition, TVA is charged with the general responsibilities for improving the Tennessee's watershed, for reforestation, and for the development of the economic and social well-being of the valley's population.

When TVA was created, in 1933, the Tennessee Valley was one of the poorest regions in the entire country. Two centuries of abuse had ravaged the once beautiful, wooded hills, had sucked the energy of the land, and had stripped away its covering, leaving the fields to be washed away by the rain. In winter and spring, water ran in rivulets across worn-out corn fields, many of which should never have been plowed at all. Muddy creeks surged into the Tennessee's swollen tributaries; they, in turn, carried the soil of the valley to the main river, which swept it out to the Ohio and the Mississippi. Water, the sustainer of life, had become a destroyer. An average of fifty-two inches of rain a year (as much as eighty-four inches in the mountains) fell on the valley like mercury and quickly spurted away. Crops, when they were not washed away in spring floods, were stunted by summer droughts and impoverished soil and brought little money on the sagging Depression market.

On the Tennessee it was the same with navigation. Too much water or not enough water. Wilson Dam and Hales Bar Dam, built before TVA, were as slings against an army. A network of dams was needed, but even this would not suffice if all of the rain reached the river. The land must hold more of the water where it fell. It must soak up the rain for moisture when there was no rain, and it must dissipate the destructive force of the runoff. For this the fields needed grass and the hills better forest covering. Marginal farm land must be taken out of production and covered with grass and trees. In short, the true relationship of the land and the river must be recognized and the destructive cycle reversed. The problem was not the river alone or the land alone. It was the entire drainage basin. Gifford Pinchot, one of America's greatest conservationists, put it this way:

> The forest and its relation to streams and inland navigation, to

water power and flood control; to the soil and its erosion; to coal and oil and other minerals; to fish and game; and many another possible use or waste of natural resources—these questions would not let me be. What had all these to do with Forestry? And what had Forestry to do with them?

Here were not isolated and separate problems. My work had brought me into touch with all of them. But what was the basic link between them?

Suddenly the idea flashed through my head that there was a unity in this complication—that the relation of one resource to another was not the end of the story. Here were no longer a lot of different, independent, and often antagonistic questions, each on its own separate little island, as we had been in the habit of thinking. In place of them, here was one single question with many parts. Seen in this new light, all these separate questions fitted into and made up the one great central problem of the use of the earth for the good of man.[1]

Perhaps the key to the Tennessee's problem was to be found in Pinchot's classic conception of 1907.

The Tennessee's problem? The government had been struggling with it for more than a century—since 1824, to be exact, when Secretary of War John C. Calhoun sent a report to President Monroe recommending improvements on the Tennessee as part of a national program to connect the various parts of the country by roads, canals, and river channels. While the Tennessee had all of the problems of any other river its size, it was further cursed with the Shoals. Some geologists believe that the river left a southerly course thousands of years ago and cut across the Cumberland Plateau into the greater Mississippi Valley. If this is true, it found its new bed uncomfortable, for it came down upon rugged shoals just as it turned north. Except during seasons of low flood, the Shoals had the effect of breaking the river in two. Frequently it was navigable above and below the Shoals, but a boat of any size could rarely put out from Knoxville with the expectation of reaching Paducah or New Orleans.

Several attempts were made during the nineteenth century to create a reliable channel. The first, following Calhoun's recommendation, was completed in 1836 but was washed out the following year. Channel clearing in 1852, just below Chattanooga, met with some success but had no effect on the Shoals. Between 1875 and 1890 canals were built

[1] *Breaking New Ground* (New York: Harcourt, Brace & Co., 1947), p. 322.

Built between 1875 and 1890, the canal above was useless during many periods of seasonal high and low water levels. It was covered with water after the gates of Wheeler Dam were closed.

in the Shoals area. Though inadequate, they were kept in use until after the closing of Wilson and Wheeler dams.

It should be noted that these early projects had but one purpose—navigation improvement. No serious hope had yet been held for flood control, and hydroelectric power was still in incubation during most of the century. But around 1880 such developments occurred in both the electric light and the electric generator that within a score of years there was to rise a great new electric power industry, and one of its chief sources of convertible energy was running water. This necessitated the damming of rivers for waterfalls, and dams meant long stretches of deep, slack water, which could be a boon to navigation.

By 1900 the need for electricity had become so great, and the methods for generating it so much improved, that the industry was searching for new and more profitable plant locations on our major rivers, including the Tennessee. However, if the power industry had reached big-business proportions, it had done so at a time when the entire

country was actively hostile to big business. The Sherman Antitrust Act, the muckrakers, and other reform movements were indicative of the people's resentment toward many of the bad practices of business, not the least of which was an irresponsibility in using the nation's natural resources. By 1890, Congress had already placed certain restrictions on the damming of navigable rivers, and while these restrictions were not severe, they were strong enough to prevent one power company from building a dam at Muscle Shoals, despite the company's authorization by Congress to do so.

If the nineties had been noted for their antitrust sentiments, the first decade of the new century was to be remembered for its efforts in conservation. The assassinated President McKinley had been in his grave less than three months when, in 1901, Theodore Roosevelt delivered his first presidential message to Congress, in which he sounded the call to arms for a conservation crusade that is still being waged today.

> The water supply itself depends upon the forest. In the arid region it is water, not land, which measures production. The western half of the United States would sustain a population greater than that of our whole country today if the waters that now run to waste were saved and used for irrigation. . . .
>
> The forests alone cannot, however, fully regulate and conserve the waters of the arid region. Great storage works are necessary to equalize the flow of streams and to save the flood waters. Their construction has been conclusively shown to be an undertaking too vast for private effort. Nor can it be best accomplished by the individual states acting alone.[2]

Implementing his ideas on conservation, T.R. vetoed, in 1903, the last bill that would have permitted a dam to be built at Muscle Shoals by a private company. With this veto was sent a message to Congress in which the President laid down one very practical principle underlying the government's part in the later development of not only the Tennessee but also many other navigable rivers with hydroelectric power potential.

> Wherever the Government constructs a dam and lock for the purpose of navigation there is a waterfall of great value. It does not seem right or just that this element of local value should be given away to private individuals of the vicinage, and at the same time the people of the whole country should be taxed for the local improvement.

[2]*Congressional Record*, Vol. 35 (December 3, 1901), pp. 85–86.

> It seems clear that justice to taxpayers of the country demands that when the Government is or may be called upon to improve a stream *the improvement should be made to pay for itself, so far as practicable.*[3]

One dam was built by a private company, however, just below Chattanooga, near the site of the 1852 improvement project. Hales Bar Dam was started in 1905 and completed in 1913. By law it was to be assigned to the government, but it was unsatisfactorily constructed and never accepted by the government until TVA took it over in 1939 (see p. 48).

The Muscle Shoals site remained in dispute. Because of the river's rapid descent at this point it was an ideal location for a hydroelectric plant. In addition, because of navigation needs, the government was eager to have the Shoals covered with deep water. After a series of proposals by private corporations for building a dam here, none of which were acceptable, the government elected to build the dam as a defense project. In 1916, World War I was in its second year, and although the United States was not to become involved until 1917, it was clear that we had to build up our military strength. The National Defense Act had authorized the construction of nitrate plants to fulfill government needs in the manufacture of explosives, and abundant electric power would be essential in the nitrate processing. Thus, in 1917, President Wilson chose the site at Muscle Shoals for two nitrate plants and a dam to supply the hydroelectric power to operate them.

The controversy over the building of the dam at the Shoals was only a mild anticipation of the furor over its disposal following the war. Since nitrates were no longer needed for munitions, the nitrate plants were considered for disposal also. There was much sentiment for the sale of all the Shoals properties to private enterprise; many people, on the other hand, thought that the government should keep and operate the dam and nitrate plants, not for munitions but for fertilizer, which could be sold to farmers at low cost to revitalize fields overworked during the war. Only a few saw the Muscle Shoals properties as the first step in a broad development plan for the Tennessee Valley.

Among the proposals to purchase these properties was one from Henry Ford. Although it was among the best offers made, its acceptance would have violated the Federal Water Power Act of 1920. And

[3] *Congressional Record*, Vol. 36 (March 4, 1903), p. 3071. Italics added. In this statement lies the logic behind TVA's power program. Critics of TVA often point to its cost as an unfair burden for the taxpayer, but they fail to mention what that cost would have been without the revenue from power sales. It was the prospect of this revenue that brought TVA within the range of possibility.

besides, Ford could have resold a small part of the whole for more than his purchase price.

It is not surprising that the Senate committee objecting to Ford's offer was headed by Senator George Norris, progressive Republican from Nebraska. Probably more than to any other person, it is to him that the credit for the inception of TVA must go. Throughout the twenties he fought against proposals for the foolish and costly sacrifice of the Muscle Shoals properties to private concerns, while he actively sponsored several bills for federal maintenance and development of not only the nitrate plants and Wilson Dam but the entire Tennessee River Valley as well. Two presidents, Coolidge and Hoover, vetoed Norris-sponsored bills of this nature, President Hoover saying of one of them, "That is not liberalism, it is degeneration."

Although Hoover failed to respond to it, the demand for government action in the valley was growing strong. In 1930, less than a year before his veto, the Army Corps of Engineers had transmitted to Congress the results of an eight-year study of the Tennessee Valley, including a program for a series of dams to be built on the Tennessee for purposes of controlling floods and improving navigation.

The nitrate plants at Muscle Shoals were taken over along with Wilson Dam by TVA in 1933 and used as fertilizer laboratories. In 1947, TVA began an expansion program with its new chemical engineering building (left center).

Another factor that Hoover apparently overlooked was public sentiment—which undoubtedly influenced the engineers' report—resulting from the disastrous floods in the valleys of the Mississippi in 1917, 1926, and 1927, the first striking the Tennessee most memorably.

It would be unjust, however, to suggest that Hoover was simply being obstinate or trying to fight single-handedly for outmoded ideas. His veto symbolized an attitude that was prevalent among conservative, business-minded politicians of the twenties. Wilson Dam and the nitrate plants represented for most of them a source of power and revenue only; the value of these installations to the national welfare in terms of flood control, navigation, conservation, or economic development was not sufficiently apparent at that time to win them over. Thus, the entire controversy over Muscle Shoals revolved around the truncated question of public versus private enterprise. Different, and harder, economic conditions were needed before the issues could appear in a clear light.

Early in 1933 the general attitude in Washington was vastly different. For one thing, the Depression had gripped the nation, and it was obvious that unemployment had to be relieved and the economy given a boost. The liberal minority of the twenties had become the majority in
10 Congress, and the conservative Mr. Hoover had been replaced by Franklin D. Roosevelt and the Brain Trust, eager to get on with their new liberal program, the New Deal. Among Roosevelt's early proposals to Congress was legislation creating the Tennessee Valley Authority. His message to Congress of April 10, 1933, contained the following:

> The continued idleness of a great national investment in the Tennessee Valley leads me to ask the Congress for legislation necessary to enlist this project in the service of the people.
>
> It is clear that the Muscle Shoals development is but a small part of the potential public usefulness of the entire Tennessee River. Such use, if envisioned in its entirety, transcends mere power development: it enters the wide fields of flood control, soil erosion, afforestation, elimination from agricultural use of marginal lands, and distribution and diversification of industry. In short, this power development of war days leads logically to national planning for a complete river watershed involving many states and the future lives and welfare of millions. It touches and gives life to all forms of human concerns.
>
> I, therefore, suggest to the Congress legislation to create a

> Tennessee Valley Authority—a corporation clothed with the power of government but possessed of the flexibility and initiative of a private enterprise. It should be charged with the broadest duty of planning for the proper use, conservation, and development of the natural resources of the Tennessee River drainage basin and its adjoining territory for the general social and economic welfare of the nation.[4]

On the following day, Senator Norris reintroduced such legislation in the Senate. A similar bill was introduced in the House, and on May 17 a compromise bill emerged from Congress. The next day, May 18, 1933, the Tennessee Valley Authority Act was signed by the President and made law. The TVA Board of Directors—Arthur E. Morgan, Chairman, David E. Lilienthal, and Harcourt A. Morgan—appointed by the President, named the first project at Cove Creek, in Tennessee, in honor of the valiant Senator from Nebraska. A contract was drawn up with the Bureau of Reclamation for the design of Norris Dam (based on previous studies by the Corps of Engineers), and TVA's construction program got under way.

Today, twenty-five years later, we may look back and ask what the results of this unique undertaking have been. A hydraulic engineer might be most impressed by TVA's incredible record in flood control, from which the savings in property losses alone are estimated to be equivalent to the cost of several of the dams. An economist would certainly be struck by the prosperity of the valley and the fact that the income level here has risen over 350 per cent since 1929, as against a national average rise of 250 per cent. An industrialist might measure TVA's success by the 502 per cent increase in income from manufacturing, compared with a national average of 321 per cent. A farmer would take more notice of the thriving state of the countryside—the beautiful, fertile green fields, the well-kept houses and barns, 95 per cent of which enjoy the use of TVA's low cost electric power. No vacationer fails to comment on the recreational resources created by the many lakes (and there are many times more fish in them than ever before, despite a year-round fishing season). An old riverboat captain would be astounded at the commerce on the once quiet Tennessee, on which it is estimated that the number of ton-miles of shipping has increased sixty-five times since 1933—from 33 million to 2.1 billion per year—and most of it in long hauls, which were rare in the last century.

[4] *Muscle Shoals Development*, U. S. 73rd Cong., 1st sess., H. Doc. 15 (1933), p. 1.

A political scientist might marvel at the effectiveness of TVA's organization and administration: a government corporation, TVA has succeeded well in not antagonizing the state and local governments in the region. Moreover, it has won their admiration, support, and complete co-operation. One governor of Georgia said, "The only complaint I have regarding TVA is that its influence has not permeated this state further."

The achievements of TVA have been manifold, but in the dramatic structures pictured on the following pages, we find its living presence. One need not be an expert at anything to recognize that here indeed is something magnificent, something for Americans to be proud of.

Nebraska's Senator George Norris, standing before the dam named in his honor, was a prime force in the creation of TVA.

Norris

length	1,860 ft.
maximum height	265 ft.
construction started	october 1, 1933
construction completed	july 28, 1936
generating capacity	100,800 kw
cost	$31,500,000

CHAPTER II

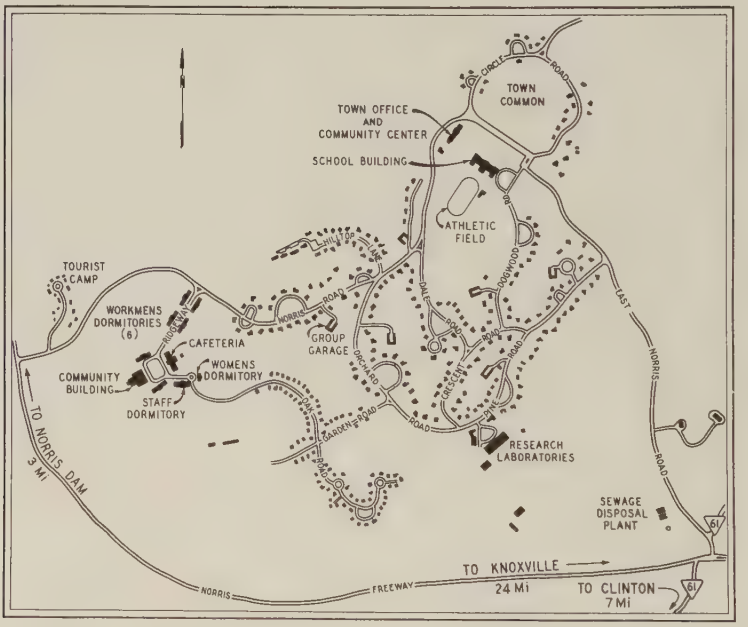
While the Bureau of Reclamation was studying the plans and data of the Army Engineers' Cove Creek project, the TVA Board of Directors issued orders for the construction of a permanent village—Norris—near the dam site. The small staff of the Land Planning and Housing Division of TVA was given the task of planning and designing the village in as short a time as was humanly possible. The Depression was at its worst in 1933, and a compelling urgency was keenly felt by everyone who could in any way help to relieve the unemployment epidemic that had paralyzed the country. Thus, in one month's time the Land Planning and Housing Division had produced a plan for the town of Norris, Tennessee, which was to be located three miles from the dam construction area. This was a remarkable feat, and all the more so since the Directors had not clearly determined what the character and purpose of the new town was to be. One member of the Board saw it as a training ground for the unskilled workers in the area who would soon be helping to build Norris Dam. All three Directors were agreed that Norris was to be a permanent community, perhaps to serve as a suburb of Knoxville, twenty-five miles away. The added expense of a permanent village over a temporary one would, it was felt, be more than offset by its subsequent sale; whereas a temporary camp would have been charged entirely to the cost of the dam.

Altering their original program for 1,000 homes, the planners finally settled on a more modest beginning, and Norris was laid out to include 294 houses, 9 duplex houses (18 units), and 5 apartment buildings (30 units). Whereas it had first been hoped that low-income rural families would occupy the houses, it soon became apparent that somewhat higher-income families would have to occupy them, especially the first group of 152, some of which were used to test domestic electrical equipment. The second group of eighty did not include such luxury features and were built of less expensive materials, though still intended as permanent dwellings. For the most part, the houses were small, one-story cottages. But a few of the more expensive ones, for the larger families, were two-story; and, while none of them was of "contemporary" design, they all reflected some of the characteristics

of modern houses of the nineteen-thirties. In general, they were unusually open in plan, with a minimum of hallways, partitions, and wasted space; and their interior use of wood was relatively daring.

The plan of the town itself offered the designers a great deal more freedom. If everyone had strong feelings about house design, practically no one had prejudices about a town-planning program of this type. Most existing examples of town planning consisted of neighborhood developments within, or just outside, established cities; but this was to be a whole community, enduring and self-sufficient. One important thing was learned by the planners, however, in their study of other town-planning endeavors, and that was the necessity for a belt of public land around the residential area to keep it free from commercial and industrial encroachment in future years.

The topography of the land chosen for the town was in many respects ideal. While it presented some problems in laying underground utility lines, the rolling, semi-wooded acreage invited an informal, imaginative plan with curved streets and walks. The houses were built



Pockets created by the winding streets of Norris provide safe playgrounds for children. Economical group garages for thirty cars were built at convenient locations. Norris Freeway by-passes the town, minimizing through traffic.

not in rows facing the streets but back from the streets at the best angles to catch the sun, the breeze, and the view. So well-planned are the streets, generally, that only three major intersections are made with Norris Road, the main thoroughfare (not to be confused with the Freeway, which by-passes the town).

At the north end of town is the Common, surrounded by a circle of houses, and opposite a cluster of public buildings, including the school. At the west end, nearer the dam, was built a group of temporary wood structures to accommodate the work gangs during the height of the dam construction period. These have been either disassembled and moved away or else remodeled to serve the needs of a settled community. The original cafeteria, for example, is now the permanent TVA Forestry Office, and the old Community Building is now Norris' Municipal Building.

In 1948, the entire town was sold by the government at auction to a private corporation for a little over $2,000,000; it was then resold to the residents, who now own all of the properties. Norris has grown in

The restaurant at Norris is typical of TVA's good design with inexpensive materials. Native wood was used for structure and finish throughout.

The community building in the foreground housed a post office, drug store, grocery store, and offices. In the background, facing the Common, is the school, with the athletic field in the rear. Since this photograph was made, several new shops have been built here.

size since the original plan and has incorporated, but it still preserves its quiet, undisturbed suburban character—a tribute to the vision of those who planned it a quarter of a century ago.

While the construction camp and town were being planned and built, the Bureau of Reclamation was pressing forward its own plans for Norris Dam. Having the benefit of the Corps of Engineers' previous study for Cove Creek Dam, the Bureau decided on a gravity-type structure (i.e., one in which the sheer weight of the concrete holds back the water) and proceeded to make the hundreds of necessary preconstruction preparations. Some men were making test drillings in the subsurface rock while others were experimenting in a laboratory with plaster models of the dam. Others were studying the probabilities and effects of earthquakes, and still others were surveying the upstream river banks, which would soon be covered by the backed-up water. All the trees between the existing and future shorelines had to be cleared off, for otherwise they would later die, be swept downstream, and cause trouble to navigation and in the operation of the dam. Land had to be appraised and bought by TVA for thousands of yards on

This brick and frame house (*right*) is one of the more expensive. Despite the required building speed, trees were saved around the houses, providing welcome shade.

Both the exterior and interior of this small house reveal good handling of natural wood. Shakes and board-and-batten siding give a warm texture, as do the paneling and stone fireplace inside.

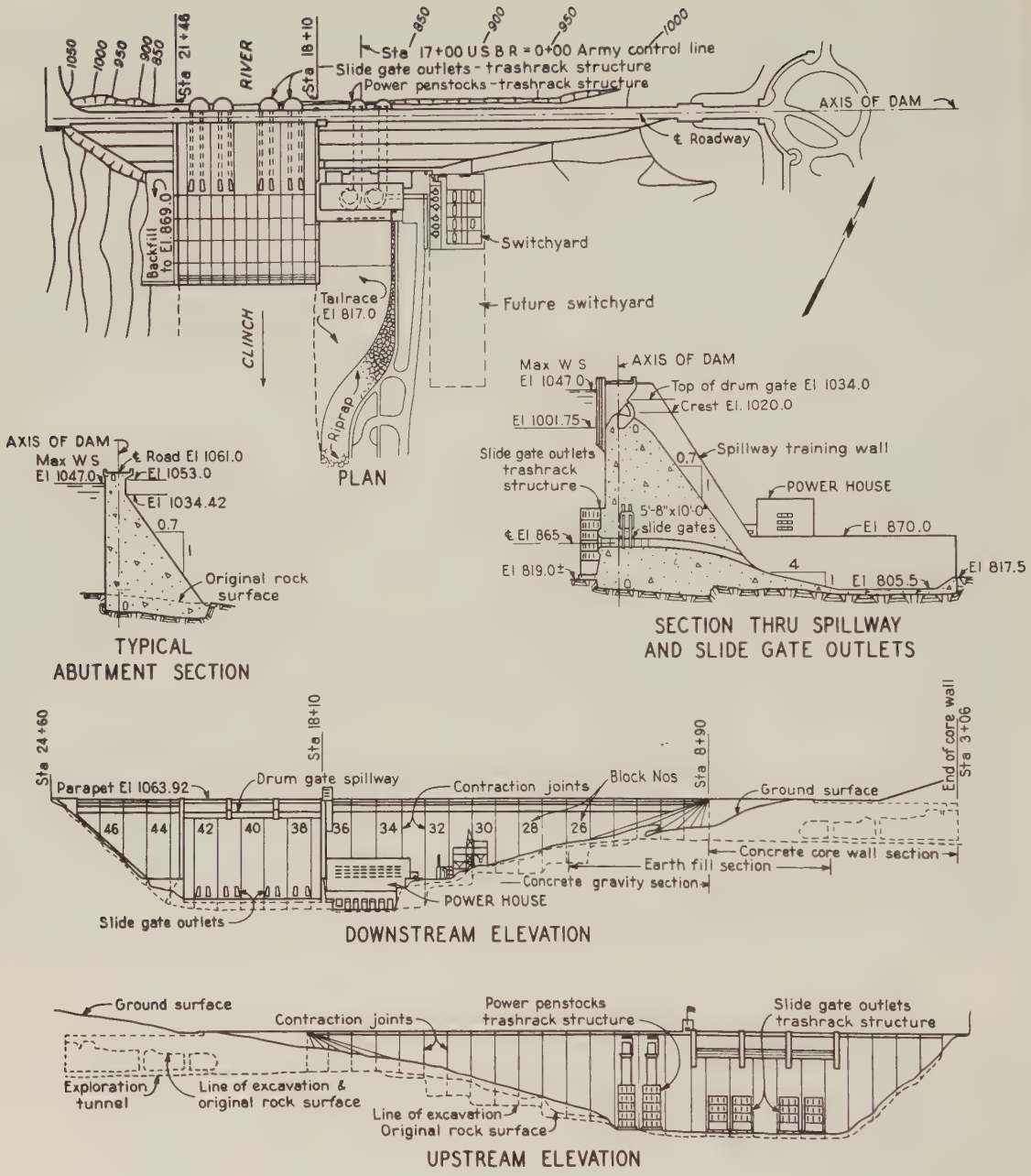
both sides of the Clinch and Powell rivers. Roads, houses, barns, railroads, telephone lines, and graveyards—everything below the future water line had to be moved or destroyed. Families had to be moved to higher ground, often, unfortunately, against their will. TVA often had to undertake the replanning of towns and, occasionally, even had the responsibility of relocating whole communities.

Along with these preliminaries and with the building of the town of Norris, the construction of Norris Freeway was going forward. The Freeway was necessary for the transportation of men and materials to the dam site. Like the town, it was built not only to serve during the construction period but also to remain as a permanent facility, linking the town and the dam with Knoxville and the railhead at Lake City. The huge growth of traffic during the last two decades has rendered the Freeway obsolete by modern standards, but for 1933 it was an outstanding example of sound and attractive highway engineering and design.

On October 1, 1933, work at the dam site began on the east bank of the Clinch River. The gentler slope of the land to the east meant that the dam must extend farther on this side than on the west, and hence would require a longer construction period. The momentous first excavation was made where the dam's shoulder would fit into the rock abutment just beneath the earth. Soon the first cofferdam was in place, reinforced by part of the rubble gouged out of the hillside.

A second cofferdam was driven into the river on the west side, leaving a narrow gap between it and the first for the river to pass through. After the water trapped by the cofferdams was pumped out, the river bed and adjacent banks were excavated down to the sound dolomite rock formation. In the river bed the rock was solid enough, but the steep west bank was very badly weathered and rotted, and the east bank was perforated with channels and horizontal caves. To avoid serious leakage after impoundment of the river, it was necessary to grout with cement all of these holes and channels, as well as the clay-filled seams between the layers of rock. The bedrock was then chiseled—with dynamite and steamshovels—to the desired shape for seating the giant dam. Because of the angle at which the rock was found, TVA engineers, instead of specifying that it be entirely leveled, allowed part of the top layer to remain, creating a long notch parallel to the length of the dam. Finally, the rock foundation was washed clean to insure a tight fit with the base of the dam when the first batch of concrete was poured.

Norris Freeway, built by TVA, was a limited access highway connecting the Norris construction area with nearby Lake City and Knoxville, 25 miles away. Lest signs and billboards render it hazardous and spoil its scenic beauty, TVA prohibited them on the 250-ft. right of way. The Freeway became a state highway several years ago.

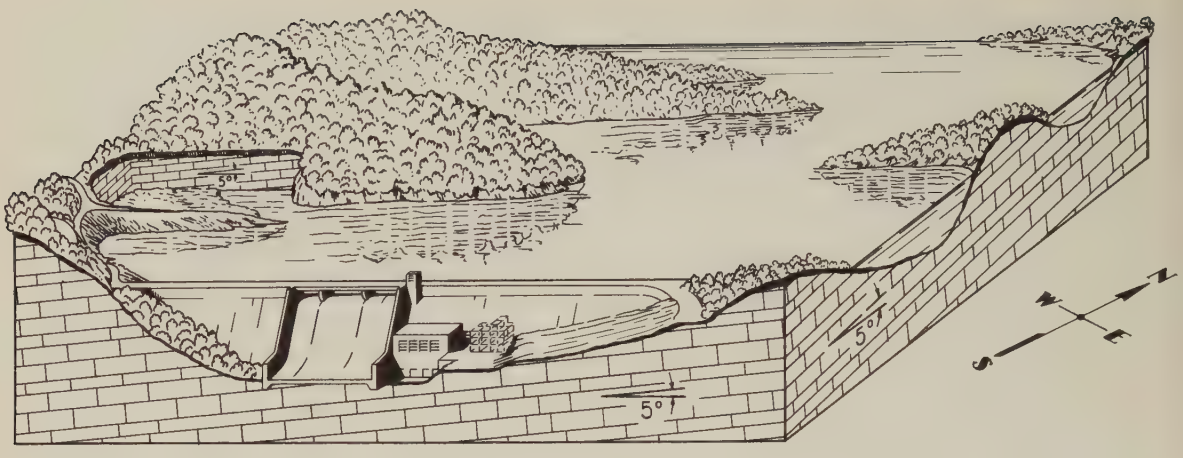


Above are drawings of Norris Dam. Notice the location of the spillway, near the west abutment. The photograph acrosspage shows the excavation work inside the first cofferdam.

A few hundred yards above the dam, on the west side, is a hill of almost solid rock, which became the stone quarry to furnish aggregate for the thousands of cubic yards of concrete that went into the dam. One of the most delightful examples of TVA planning was the handling of this quarry. Cleared of topsoil and vegetation by powerful hydraulic hoses, this hill was quarried in such a way as to help create a natural, beautifully formed boat harbor that required only a minimum amount of finishing to be made operable.

Stone from the quarry was crushed, mixed with limestone sand, and combined with cement and water, all on an assembly-line basis, as it was transported to the wood forms at the dam. Soon the dam was rising all along its length, except at the narrow gap between cofferdams, through which the river was flowing. When the height of the dam safely exceeded the depth of the river, cofferdam number three was built, the sides being erected on dry land inside cofferdams one and two. The river was then diverted to flow through completed parts of the dam, and the remaining foundation was poured over the center of the river bed. Unlike those of the other two, the sides of the third cofferdam were left standing for use throughout the rest of the construction, which is one of the reasons they were made of concrete rather than timber.

Since concrete is subject to serious thermal contraction when used in such large quantities, it was necessary to build the dam in sections, with contraction joints every 56 feet. As the large blocks set and cooled, grout was forced into these contraction joints to make them watertight.



The rock strata at the dam site slopes 5° down to the south and west. Note the relationship of the quarry to the dam.

One of the reasons for building the first cofferdam on the east side was the plan of locating the powerhouse on that side of the river, and the powerhouse construction proceeded right along with that of the dam. In fact, although the superstructure of the powerhouse is supported by steel, the lower part is monolithic with the dam.

Immediately after the rock base at the powerhouse site was covered with concrete, forms were moved into place to shape the bell-mouth entrance to the two mammoth conduits that bring water through the dam to the turbines. A pair of steel penstock liners, each 20 feet in diameter, were assembled on the site and laid at an angle of approximately 12°, sloping downward from the upstream side of the dam. Each is capable of conducting nearly 5,000 cubic feet of water per second down to the twin turbines in the powerhouse. Immediately below the turbines were built the forms for two elbow-type draft tubes, which carry the water from the turbines to the river below the dam. As concreting of the dam progressed, the scroll cases, speed rings, and turbine runners were secured, completing the path that the water would follow on its way through the dam.

The Clinch River was diverted through the slide gate outlets near the base of the dam during the last phase of construction. A foot bridge is here suspended between the walls of cofferdam number three. The hills in the background have been stripped of trees in anticipation of the high water.

Meanwhile, in the spillway sections of the dam, slide gate outlets were being completed to supplement, when necessary, the flow of water through the turbines. It was through these outlets—because they are so near the base of the dam—that the river was diverted when the third cofferdam was closed. And it is through them that most of the discharged water not used for power is released. Only infrequently are fortunate visitors treated with the spectacle of water surging over the spillway.

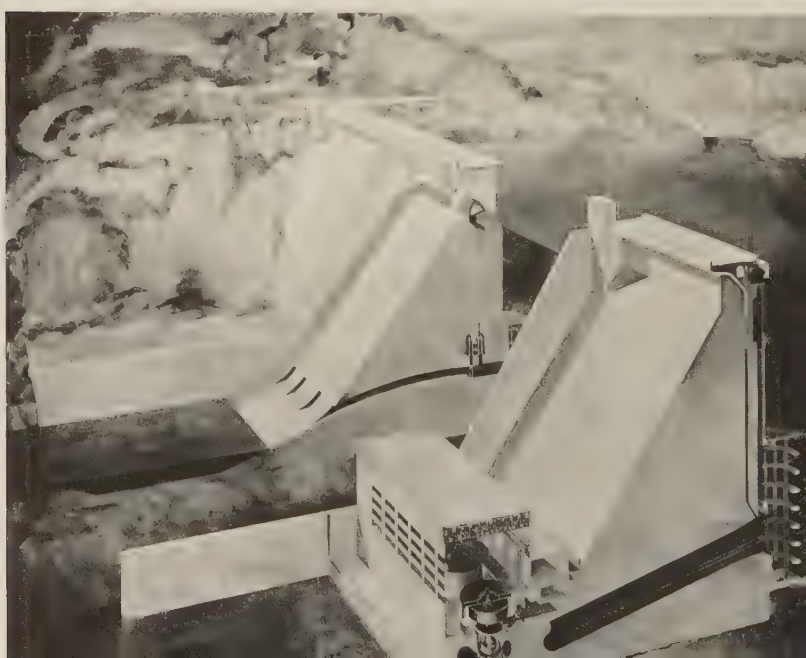
Those unfamiliar with the methods of dam construction may wonder how all the forms, concrete, and heavy apparatus are maneuvered into place; and even those who are familiar with this operation are, no doubt, still impressed when they see it. At a site like that at Norris, where the abutments rise sharply above the height of the finished dam, one fundamental system is used to bring nearly all materials—certainly all heavy materials—into place. Two derrick-like towers were erected at opposite ends of the dam (at Norris they were 1,925.5 feet apart), high up on the abutments. Between the towers ran a series of steel cables strong enough to carry many thousands of pounds. The

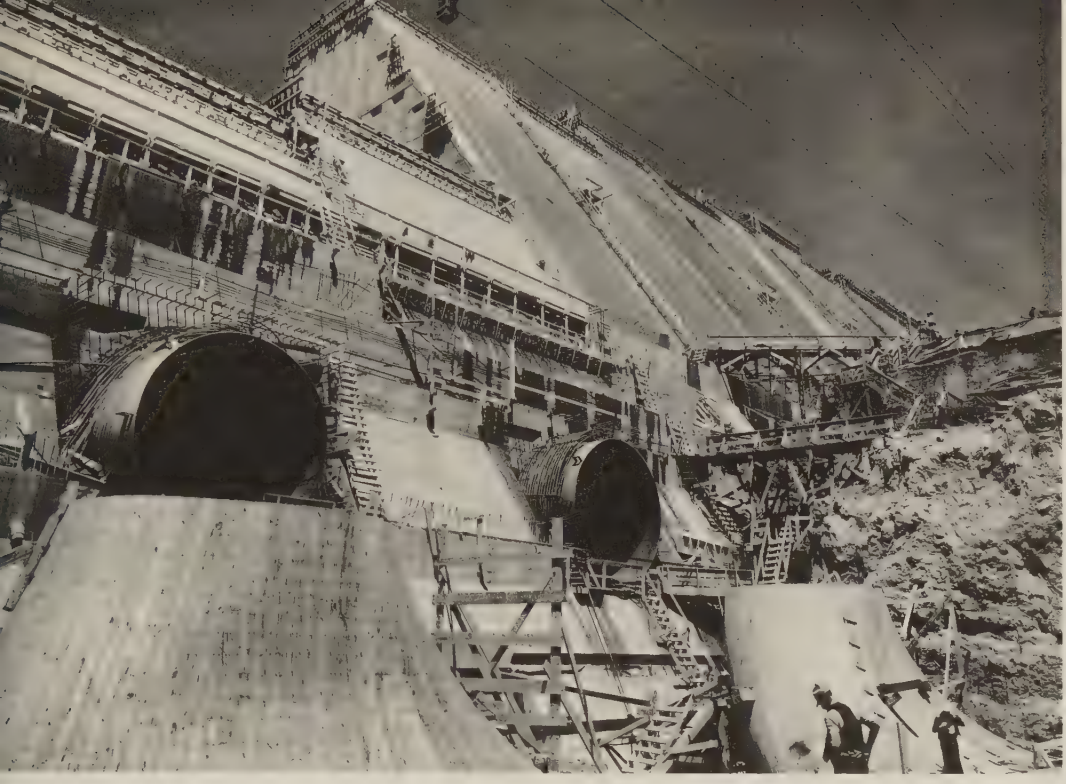
towers, moreover, were mobile; that is, they moved on tracks perpendicular to the axis of the dam. Thus, it was possible to lower large steel hooks at any point in the construction area from the upstream trashracks to the downstream aprons and from the east abutment to the west.

The materials—whether concrete buckets, heavy prefabricated sluice gates, or steel beams for the powerhouse—were brought by truck or hopper to a point directly under the cables on the west abutment. From here they were picked up by the hooks, run out on the cables, and lowered into place. It was by this means that the three drum gates, for example, were put into position at the top of the spillway.

With the completion of the elevator penthouse, the road, and the bridge at the top of the dam, two generators with a capacity of 50,400 kilowatts each were installed in the powerhouse; the switchyard was hooked up to the generators; and Norris Dam was virtually finished, after almost three years of construction. In May of 1936, the gates of the dam were closed, and impoundment of the Clinch River began. By the end of July, the first generator had begun spinning, thus bringing

A mural inside the powerhouse demonstrates how the dam works. Three means for discharging water are shown here: penstocks and turbines; slide gate outlets; and spillway.

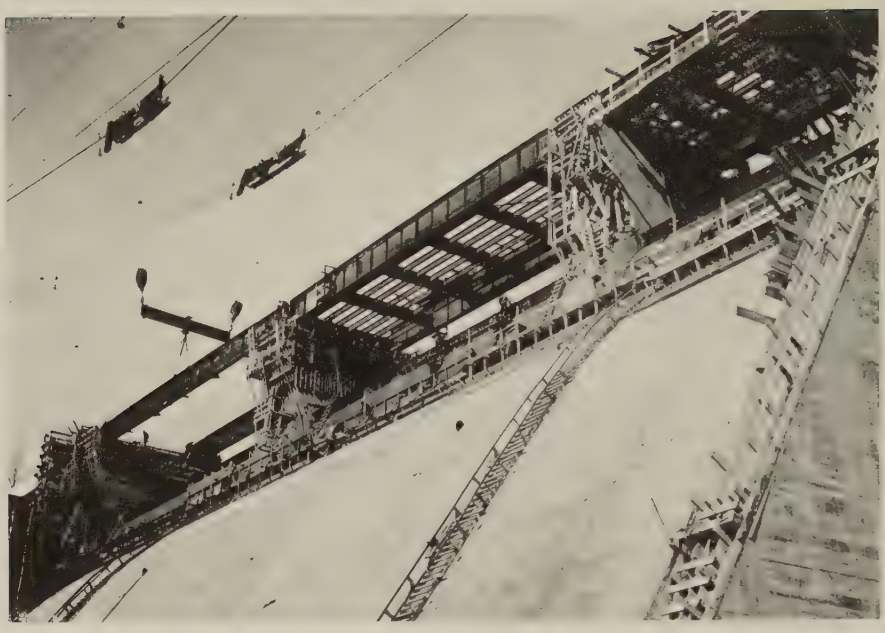




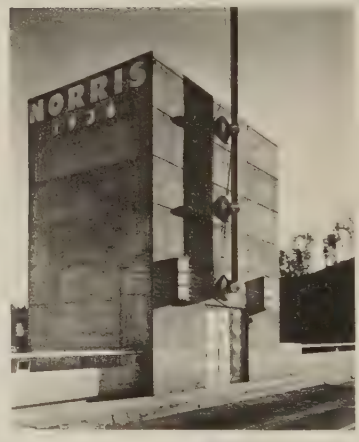
Penstocks and draft tube forms are shown before the turbines were installed. Next step: draft tube forms will be covered with concrete, brought in by buckets on cables (*top*).

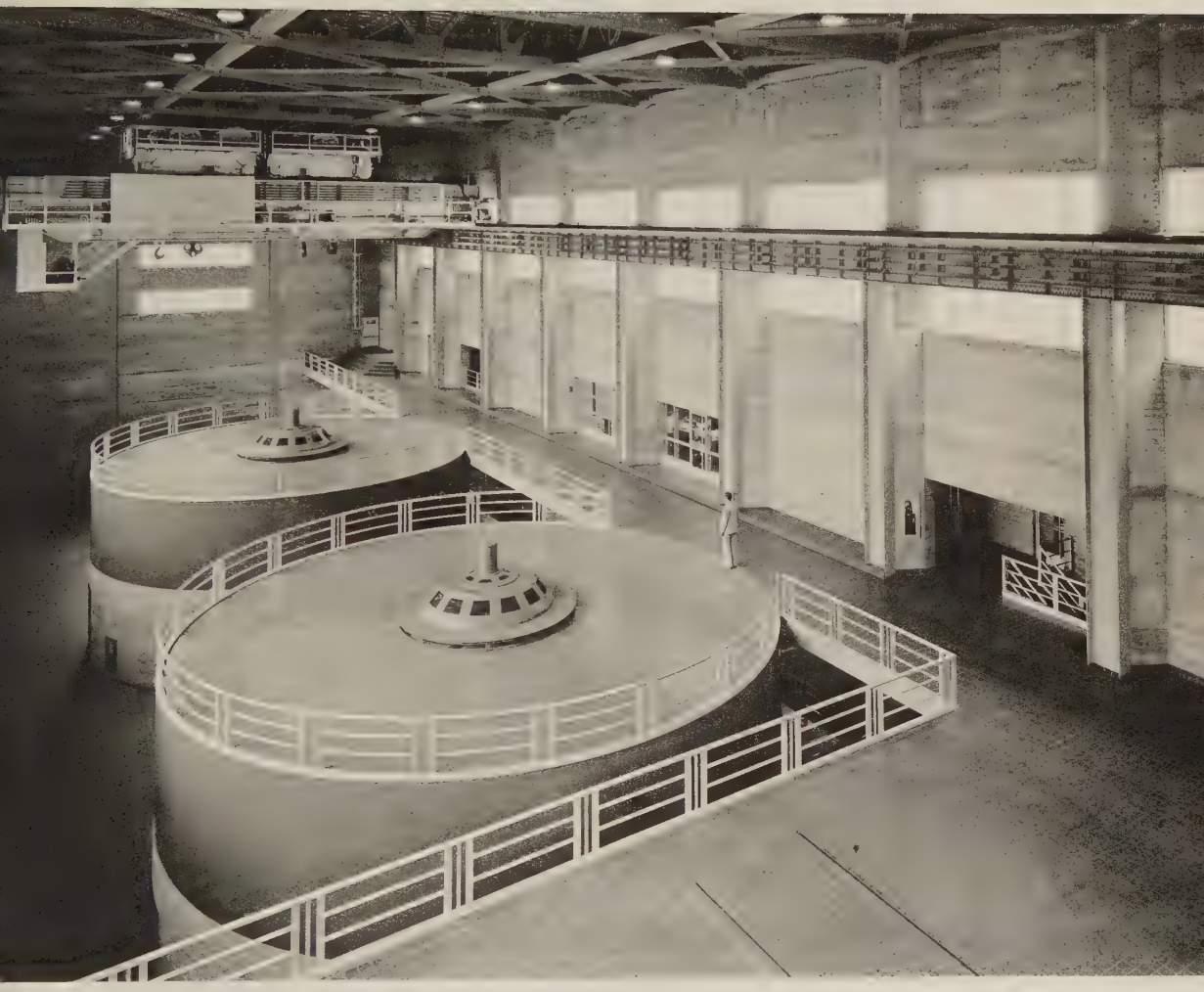
near to completion the first of twenty dams that TVA was to build in the next twenty years.

One of the values of Norris Lake that was early recognized by visitors and by TVA was its recreation potential. Although TVA did not have explicit authority to build and develop recreational facilities, it did find itself owner of eight hundred miles of shoreline, which it had bought to insure the proper maintenance of the lake. And it did have the authority to see that this land was properly used. Thus, in co-operation with the National Park Service and the Civilian Conservation Corps, TVA built and put into operation three demonstration recreation facilities in an effort to stimulate the development of a state park and recreation system on the shores of the lake.



Last to be built was the bridge over the spillway (*above* and *below*). TVA architects assisted the Bureau of Reclamation in the design of these handsome bridge piers. At right is the elevator penthouse atop the dam.





The walls of the powerhouse, both inside and out, are faced with concrete to harmonize with the dam. Notice the clean detailing of signs, lights, stair rails, and windows.

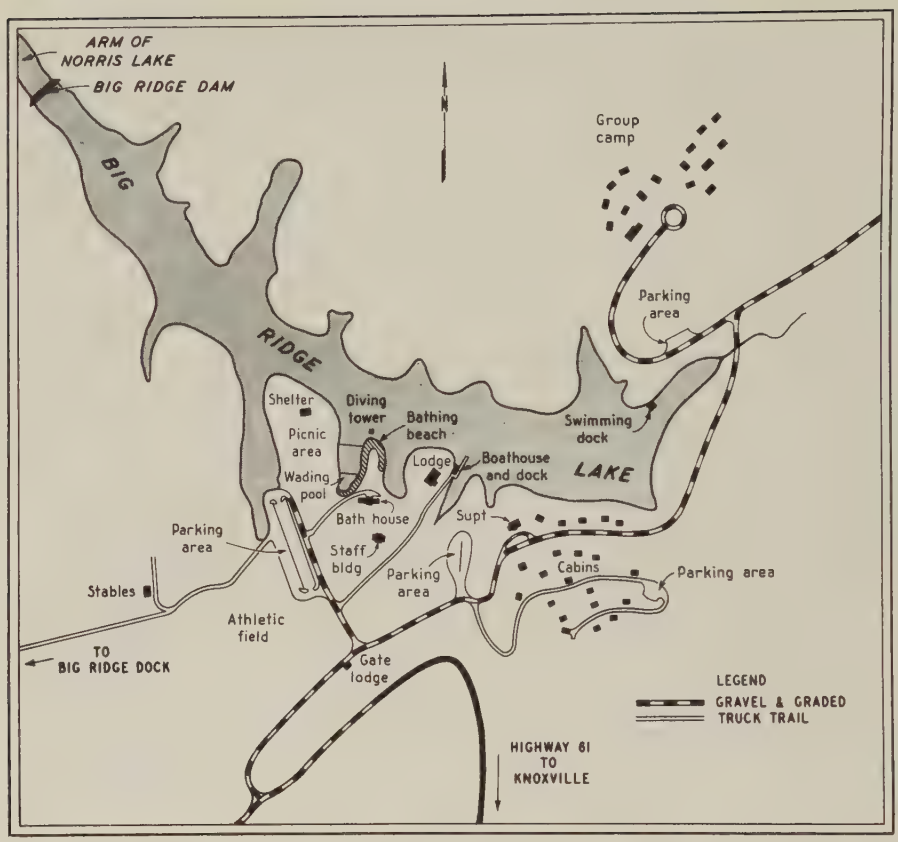
From the standpoint of design and construction, the boat harbor at Norris Dam is most interesting. To say that it was built is not quite accurate; it was actually "left" when the last load of stone was carried away from the quarry. It was, however, necessary to construct roads, walks, comfort stations, parking lots, and a boat landing, all of which was done with care and sensitivity, for this was to be TVA's signal to the builders of all subsequent shoreline facilities that such installations must be handled in responsible fashion.

Just east of the dam, TVA built Norris Park—again with the help of the Park Service and the CCC—which included a number of rustic cabins for vacationers. Designed to conform with the wooded landscape, the cabins are simple both in plan and construction. Now over twenty years old, they are still in use and can be rented from the state, which took them over several years ago.

The boat harbor was partly sculptured from the rock quarry. The floating dock and boathouses follow the draw-down of the lake in the summer and fall, sometimes nearly 100 ft.

Stone for the comfort stations at the Norris landing was taken from the quarry just behind.

On Big Ridge Lake, an arm of Norris Lake, TVA built another park —Big Ridge Park, the most extensive recreation project developed by TVA. Here are cabins, stables, bathing beaches, boat docks, and dining facilities. The cabins were built, to a large extent, from lumber and logs sawn from timber that was cleared from the banks of the lake. Big Ridge was also turned over to the state, and nearly one hundred thousand persons from many states enjoy its benefits every year.


ARM OF
NORRIS LAKE
BIG RIDGE DAM
BIG
RIDGE
Group
camp
Parking
area
Shelter
Picnic
area
Diving
tower
Bathing
beach
Swimming
dock
LAKE
Lodge
Boathouse
and dock
Wading
pool
Bath house
Supt
Parking
area
Staff
bldg
Parking
area
Cabins
Parking area
Stables
Athletic
field
TO
BIG RIDGE DOCK
Gate
lodge
LEGEND
GRAVEL & GRADED
TRUCK TRAIL
HIGHWAY 61
TO
KNOXVILLE

Norris Dam (*above*) is popular with sightseers, photographers, and Sunday-afternoon drivers. The bathing beach at Big Ridge Park (*acrosspage*) has both deep and shallow swimming areas, with a 20-ft. strip of sand around the peninsula (see plan). Recreation is now one of the valley's major industries.

The longest of all TVA dams is Kentucky, more than 1½ miles from end to end.

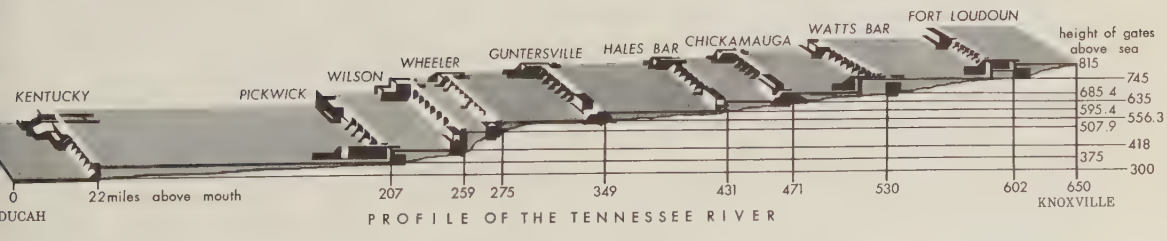
Main River Dams

CHAPTER III

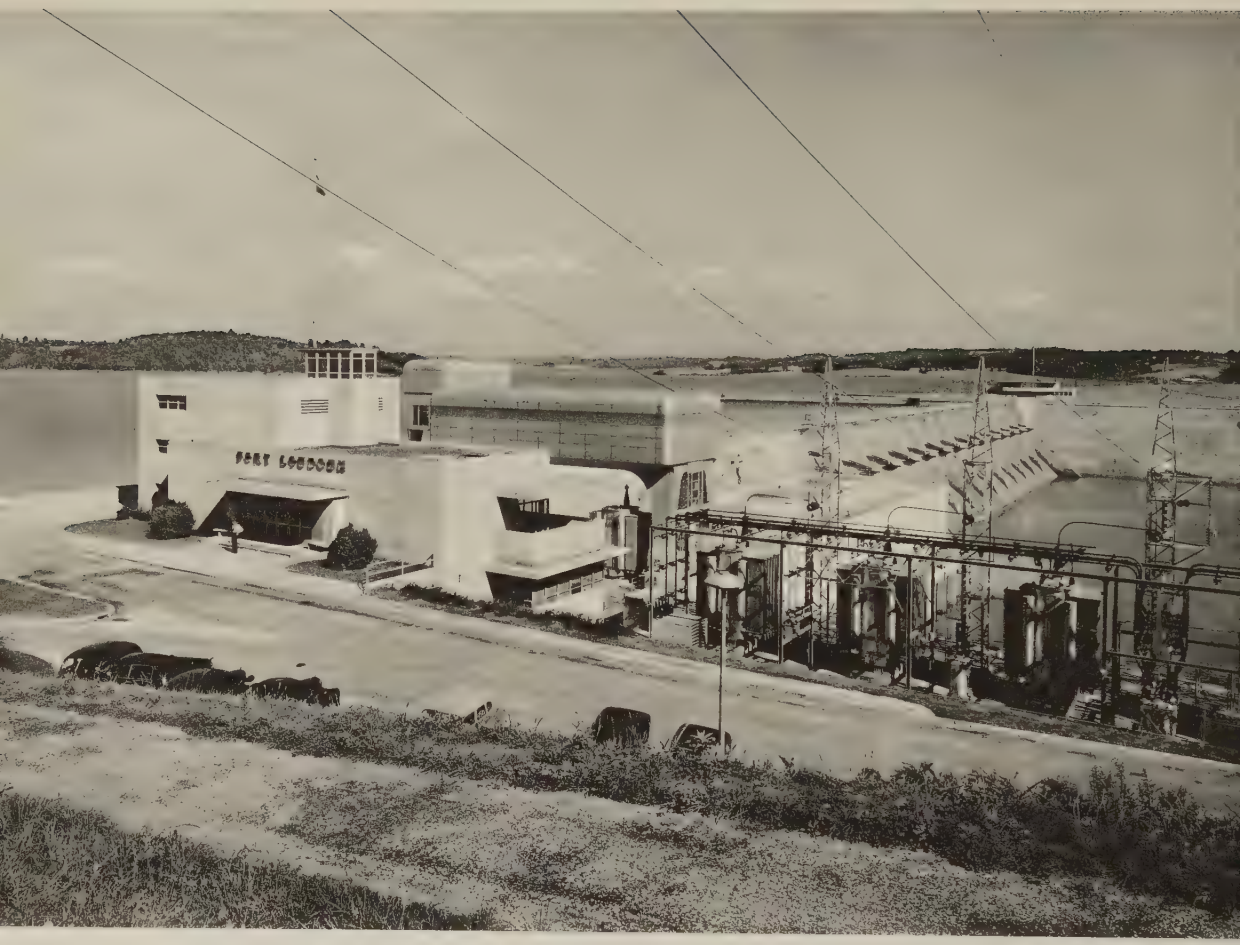
Construction of Norris Dam, on the Clinch, was under way only six weeks when, in November, 1933, dynamite crews and steamshovels set to work carving the earth and rock on the banks of the Tennessee in northern Alabama. Wheeler Dam, the first of seven multipurpose dams, was begun at the Elk River Shoals, sixteen miles above Wilson Dam.

Following Wheeler by a year and a half came Pickwick Landing, built fifty-two miles below Wilson to complete the task of covering the dangerous shoals with deep, slack water. After Pickwick came Guntersville, at the southernmost reach of the Tennessee, in Alabama. A month later, in January, 1936, ten miles northeast of Lookout Mountain, excavation was begun at the site of Chickamauga Dam.

These four dams, together with Wilson and Hales Bar dams—both built before the existence of TVA—succeeded in taming the waters of the Tennessee. All that remained to fulfill the old dream of controlling the river completely was one large dam, Kentucky, near the Ohio River, and two more near the head of navigation, Watts Bar and Fort Loudoun, between Chattanooga and Knoxville. A year and a half before the Japanese attack on Pearl Harbor all three of these dams were under construction. By the fall of 1944 the last and largest dam on the Tennessee was impounding water and generating electricity. This was the final step in a century-old struggle to make the river navigable all the way from the Ohio River to Knoxville.



PROFILE OF THE TENNESSEE RIVER



The uppermost dam on the Tennessee is one of TVA's handsomest.

FORT LOUDOUN

length	4,190 ft.
maximum height	122 ft.
construction started	july 8, 1940
construction completed	november 9, 1943
generating capacity	128,000 kw
cost	$43,000,000

The last started on the Tennessee, and the one farthest upstream, Fort Loudoun is in many respects the most harmonious of all TVA multipurpose dams. Having gained in experience and practice from the six previous dams, the architects and engineers were able here to bring into focus the sum of their knowledge and skill. Despite the pressure, at first, of an accelerated defense program and, later, of a global war (with its ensuing shortage of materials), Fort Loudoun has a unity and harmony usually found only in less complex structures. Its three main functions are immediately discernible (*below*) in its three elements: (1) in the foreground are the powerhouse and switchyard; (2) the regular buttresses shoulder the spillway gates that control potential flood waters; (3) intersecting the axis of the dam are the twin mammoth walls of the navigation lock—before the completion of the new lock at Wilson Dam, this lock was the highest single lift in the TVA system.

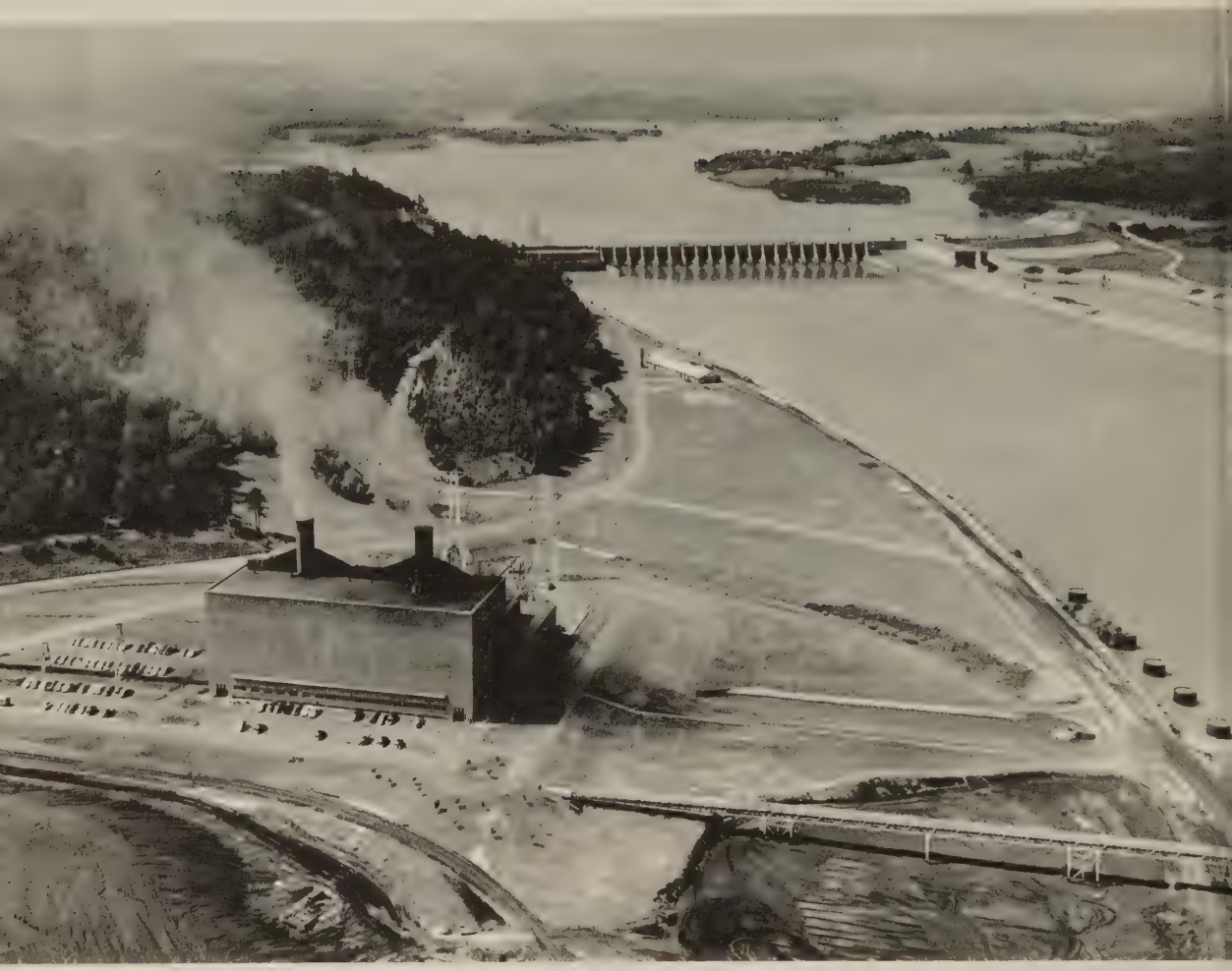
Fort Loudoun, very popular with tourists, is open to visitors mornings and afternoons, and guided tours can be arranged upon request. It is located just a few miles from Lenoir City, Tennessee.

38

This navigation lock was for many years the highest single lift (80 ft.) in the world. Measuring 60 ft. across and 360 ft. in length, it locks through millions of tons of cargo every year. The U. S. Army Engineers control all locks on the Tennessee, and no safe vessel will be denied passage, though some small boats may have to wait for as much as an hour before locking through.

The large turbine runner at left is one of four at Fort Loudoun. Like an airplane propeller, the blades are adjustable to different pitches for different speeds. The gantry crane overhead is part of the permanent installation and is used to remove the generator and other heavy equipment for repairs.

The simplicity and neatness of the control building, both inside and outside, are characteristic of TVA structures. At most plants the visitor will find explanatory graphic displays, such as the one above, and the statement, "Built for the People of the United States."



Power for national defense was produced by the dam and steam plant at Watts Bar.

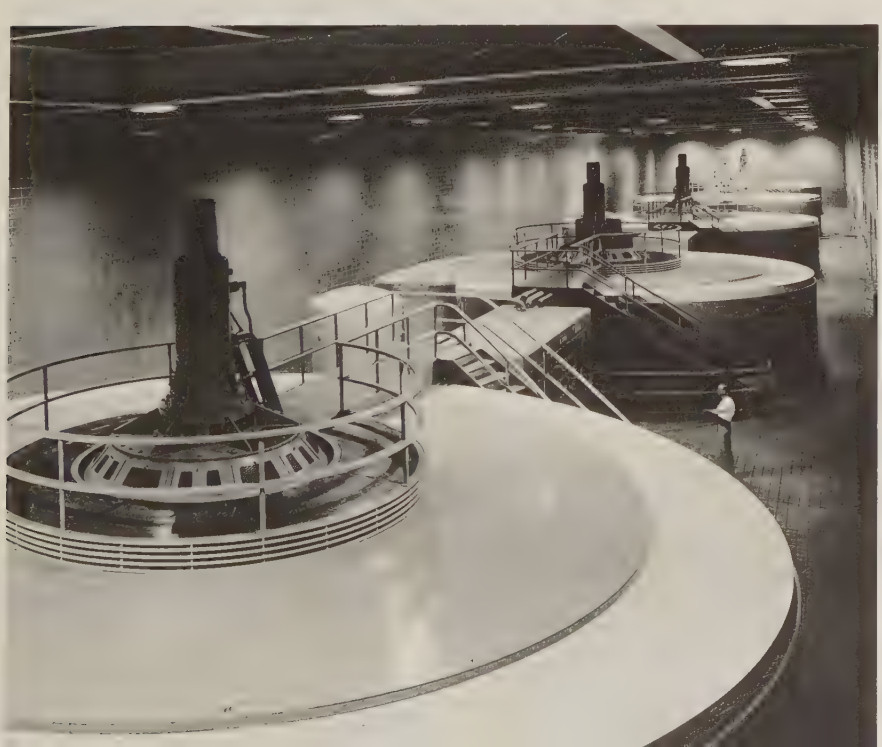
WATTS BAR

length	2,960 ft.
maximum height	112 ft.
construction started	july 1, 1939
construction completed	february 11, 1942
generating capacity	150,000 kw
cost	$35,600,000

Midway between Chattanooga and Knoxville, Watts Bar Dam was begun a year before Fort Loudoun, just before war broke out in Europe, in 1939. The original plans for Watts Bar specified that two of its ultimate five generators should be postponed until the additional power was needed. As America watched events in Europe, however, we began to mobilize our resources in a national defense program. To step up airplane production more aluminum was needed than we were then producing. In order to increase aluminum output it was first necessary to enlarge our electric power capacity, for electricity is a primary factor in aluminum production. Thus, it was decided to install all five generators at Watts Bar during the initial construction. Within a year, work had started also on the Watts Bar Steam Plant (see p. 127), less than a mile downstream. Both the dam and the steam plant were producing power early in 1942.

The rocky bluff on the north shore did not permit the control building to be located on the dam level. Elevator shafts were drilled in the rock to connect the control building with the powerhouse and dam. This photograph shows the top of the dam upon completion, in 1942. In recent years the State of Tennessee built a bridge over the dam.

Above is a view of the dam after completion of the bridge. The metal hatches on the powerhouse deck cover the generators beneath. Notice the clean, refined detail of the generators and of the lock guard wall (*acrosspage*). For contrast, compare these generators with those at Wilson Dam (p. 61).



In 1953, the State of Tennessee built a bridge across Chickamauga Dam. North Chickamauga Creek, in 1936, was diverted to empty into the Tennessee below instead of above the dam.

CHICKAMAUGA

length	: 5,800 ft.
maximum height	: 129 ft.
construction started	: january 13, 1936
construction completed	: march 4, 1940
generating capacity	: 108,000 kw
cost	: $41,000,000

In 1936 Chattanooga was the most vulnerable to flood of any city in the Tennessee Valley. Between 1910 and 1930 the river rose to flood stage no less than nineteen times, and it reached disastrous proportions three times, the worst in 1917. In late January and early February, 1957, rains that fell in the upper valley brought the second largest amount of water into the river in history. Had it not been for TVA, a crest 24 feet above flood stage would have rolled over much of the city, causing damages conservatively estimated at $66,000,000. While the damages actually sustained were slight, it is still possible—indeed, probable—that Chattanooga will see another crest like that of 1867—27.9 feet above flood stage—that even TVA cannot hold back unless additional dikes are built around the city.

Although there was no need for a bridge across Chickamauga Dam when it was built, TVA designers made provisions for one to be built later. However, since no bridge had been here before the dam, TVA was not responsible for erecting one. Thus, it was built by the state with the aid of funds from the federal government.

The cellular steel cofferdam above was filled with mud, gravel, and rocks from the river bed. Excavation began after the water behind the cofferdam was pumped out and the earth allowed to dry. Since none of the upstream dams except Norris had been authorized when Chickamauga was started, it was built with more flood gates (*below*) than it now needs to regulate the river's flow. The observation building (*acrosspage*) overlooking the navigation lock shows early TVA architecture at its best.

50

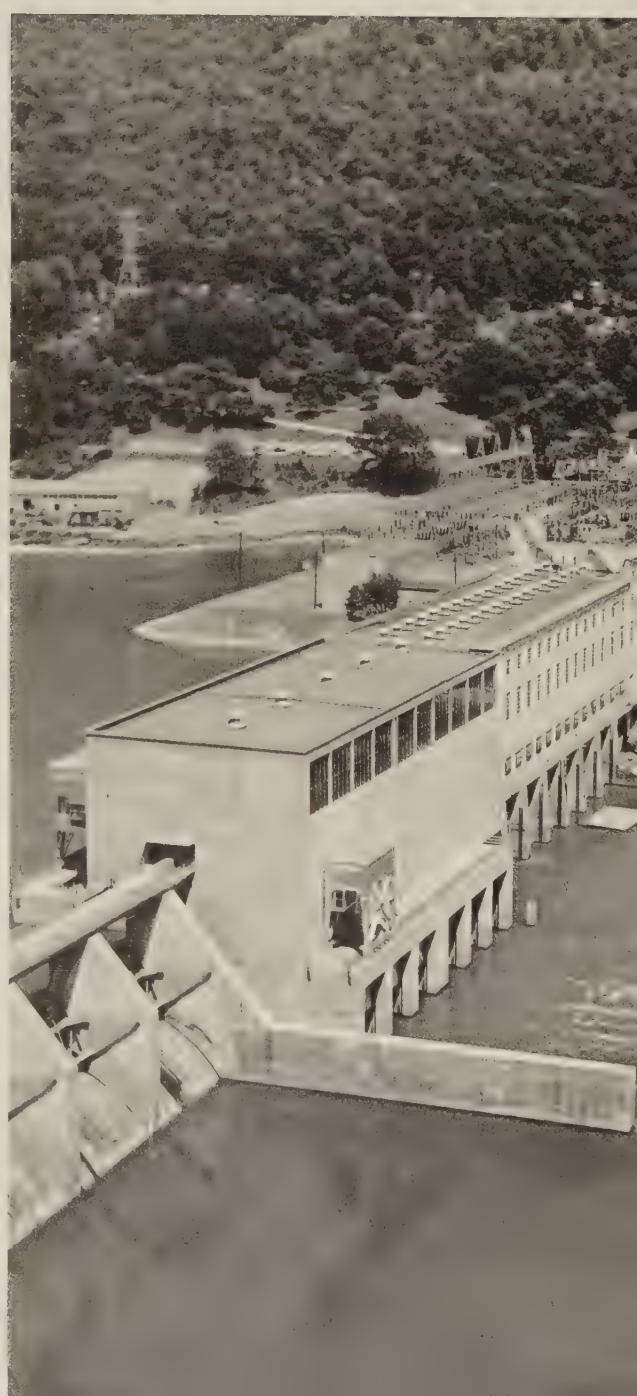
Hales Bar Dam, built in 1905–13, was completely remodeled by TVA.

HALES BAR

length	: 2,315 ft.
maximum height	: 112 ft.
TVA construction started	: december, 1940
construction completed	: july, 1952
generating capacity	: 99,700 kw
cost	: $35,600,000

When TVA purchased Hales Bar Dam (*above*) from the Tennessee Electric Power Company in 1939 for $11,686,773, several things were wrong with it. Much water was leaking through the foundation; its storage capacity was inadequate; and it operated at a low degree of efficiency. TVA cured the leakage, raised the effective height of the spillway, improved the navigation lock, and installed two additional generators in an extension of the powerhouse, each with a capacity equal to several of the existing generators.

The contrast between old and new can be seen in the powerhouse (*right*). Instead of three courses of windows, used in the old powerhouse, one economical course of glass near the roof was used by TVA to get much more natural light inside. Poured concrete was used for the outside walls of the powerhouse, harmonizing with the dam.



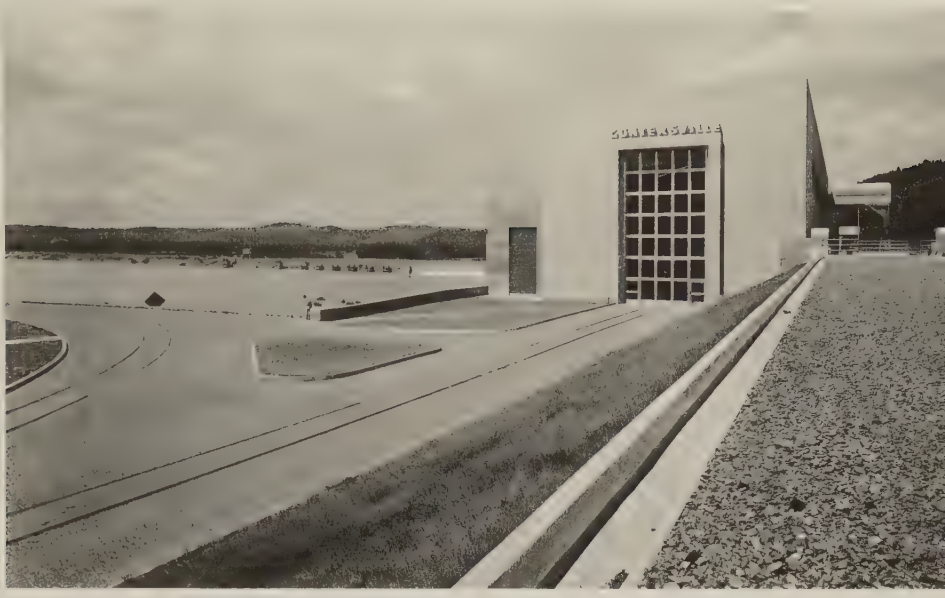
Guntersville Dam was the fourth built by TVA. It completely revitalized the town from which it took its name.

GUNTERSVILLE

length	: 3,979 ft.
maximum height	: 94 ft.
construction started	: december 4, 1935
construction completed	: august 1, 1939
generating capacity	: 97,200 kw
cost	: $39,000,000

Situated midway on the Tennessee, at its southernmost bend, Guntersville Dam completely changed the character of the area around it. The town of Guntersville (*below*), in Alabama, was a quiet, dusty little river town in 1935. Today it is an industrious, prosperous port and recreation center. When impoundment of the river began, water backed up around the town, almost surrounding it. Anticipating the change in Guntersville's shoreline, TVA had built three causeways, with bridges, to connect the new peninsula with the major highways near by. In addition, dikes were built around the eastern side of the town (*foreground*).

Like most of the main river dams, Guntersville is made of earth and rock over more than half its length, only the lock, spillway, and powerhouse sections being of concrete and steel. The capacity of the spillway is so great that no foreseeable flood could ever reach the top of the earth embankments, which would be washed out in a few hours if the river ever spilled over them.



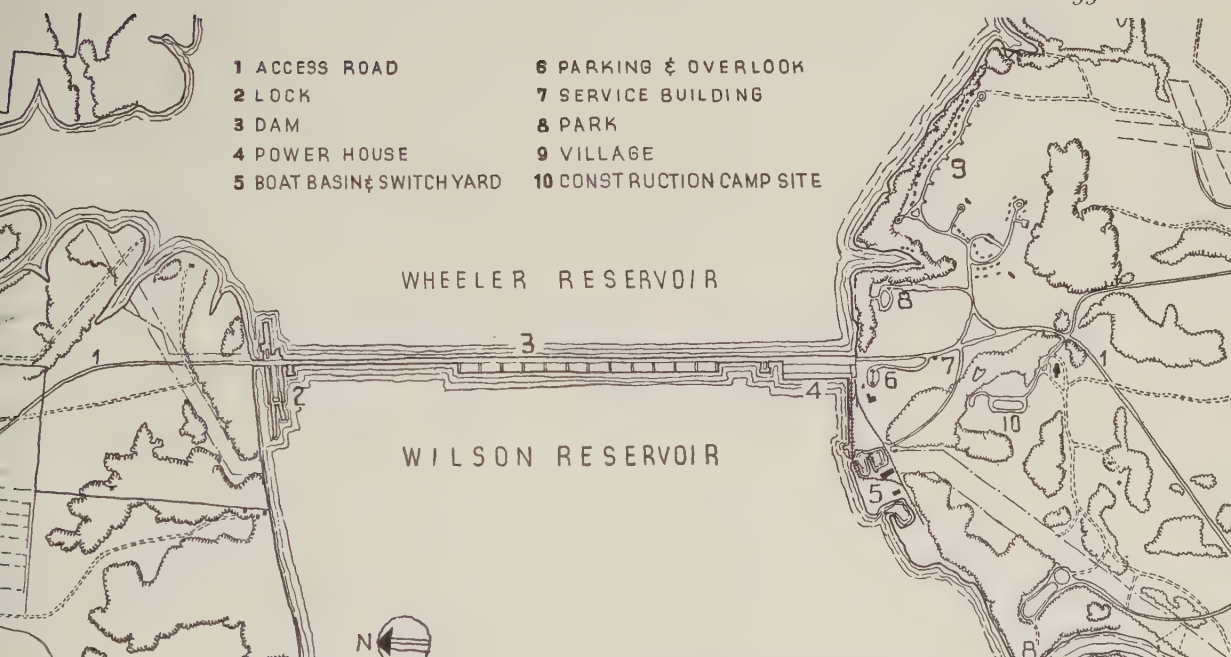
In 1932, commercial navigation on the Tennessee amounted to 33 million ton-miles, mostly in short runs, and consisting largely of sand and gravel. Today this figure is greater than 2 billion and includes everything from heavy industrial materials to fertilizer. The generators (*below*) are not serviced through overhead hatches, as at Fort Loudoun, but through the enormous door of the powerhouse.

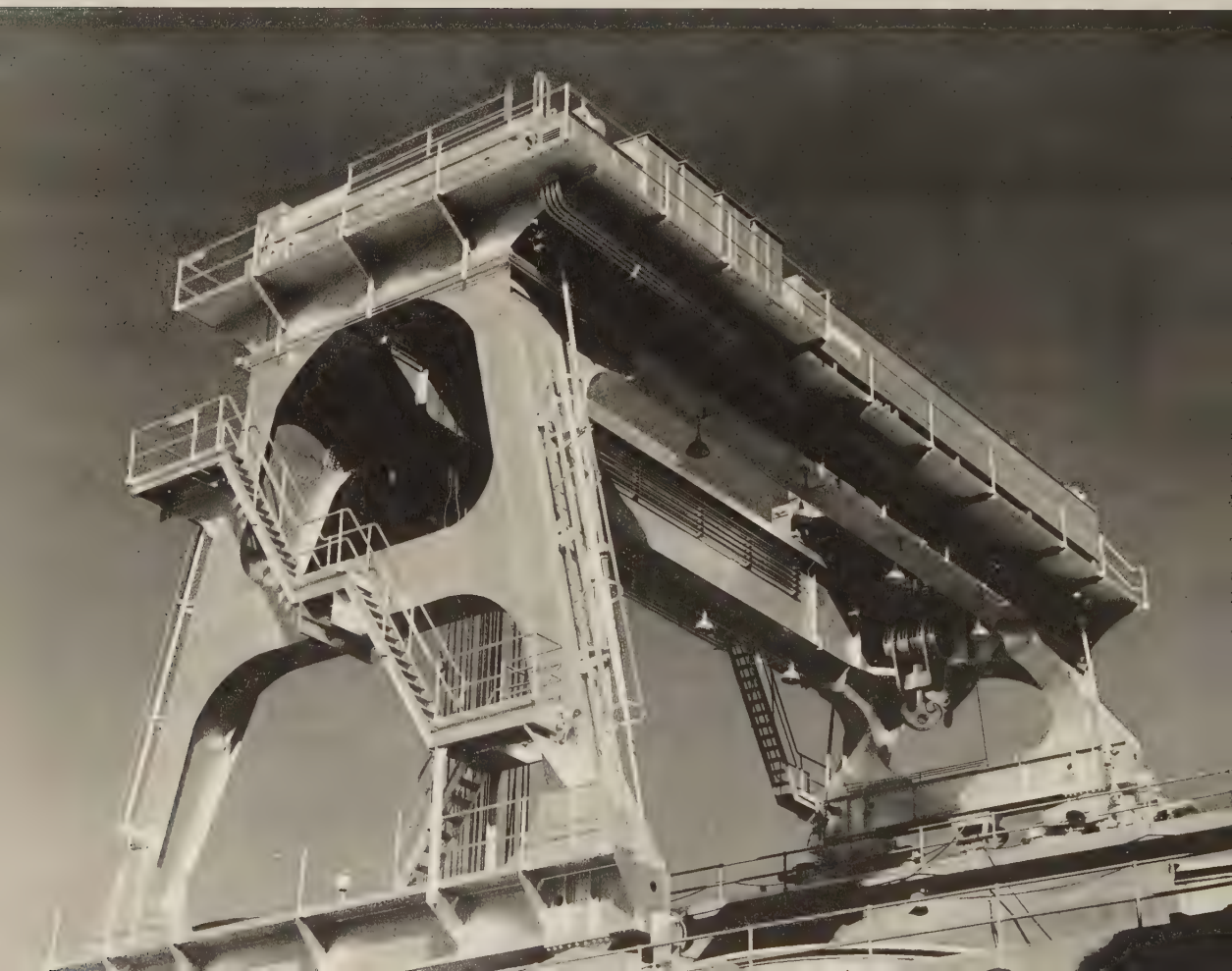
WHEELER

length	6,342 ft.
maximum height	72 ft.
construction started	november 21, 1933
construction completed	november 9, 1936
generating capacity	259,200 kw
cost	$48,200,000

The lowest of TVA's main river dams, Wheeler is approximately 1.2 miles long. Unlike other TVA dams, it has no enclosed generator room, and the generators spin under exposed steel cowlings. By the time TVA took over the design and construction of Wheeler, in 1933, the design of the lock by the Corps of Engineers was nearly completed, and the design of the dam and powerhouse by the Bureau of Reclamation was well advanced. Perhaps because of the dam's unimpressive height, TVA's architects and engineers were not as fortunate in their design improvements here as they were at Norris. Yet the generator platform, partly screened by transformers and transmission towers, affords a handsome composition in metal—lines, volumes, planes, and textures.

The plan (*below*) shows the relationship of the dam to its immediate surroundings—roads, docks, construction camp, and community. As at other TVA projects, the construction facilities were converted to maintenance and recreation facilities.





The north end of Wheeler, between the lock and spillway, is a non-overflow section from which the road across the dam (*right*) rises up over the lock (*acrosspage, top*). The concrete piers (*above*) are monolithic with the dam in the non-overflow section but give way to combination concrete and steel-truss piers near the lock. The steel trusses of the bridge were fabricated on the shore, brought into location by barge, and lifted into place. While this bridge is perfectly adequate, TVA designers were later to produce some of the most attractive bridges in America (see Chap. v). Old fashioned now perhaps, the giant gantry crane at left is still an extremely handsome structure. This type of equipment, also, was much improved upon by TVA designers later.

Built only fifteen years before Norris, Wilson Dam is an example of confused eclecticism in American architecture.

WILSON

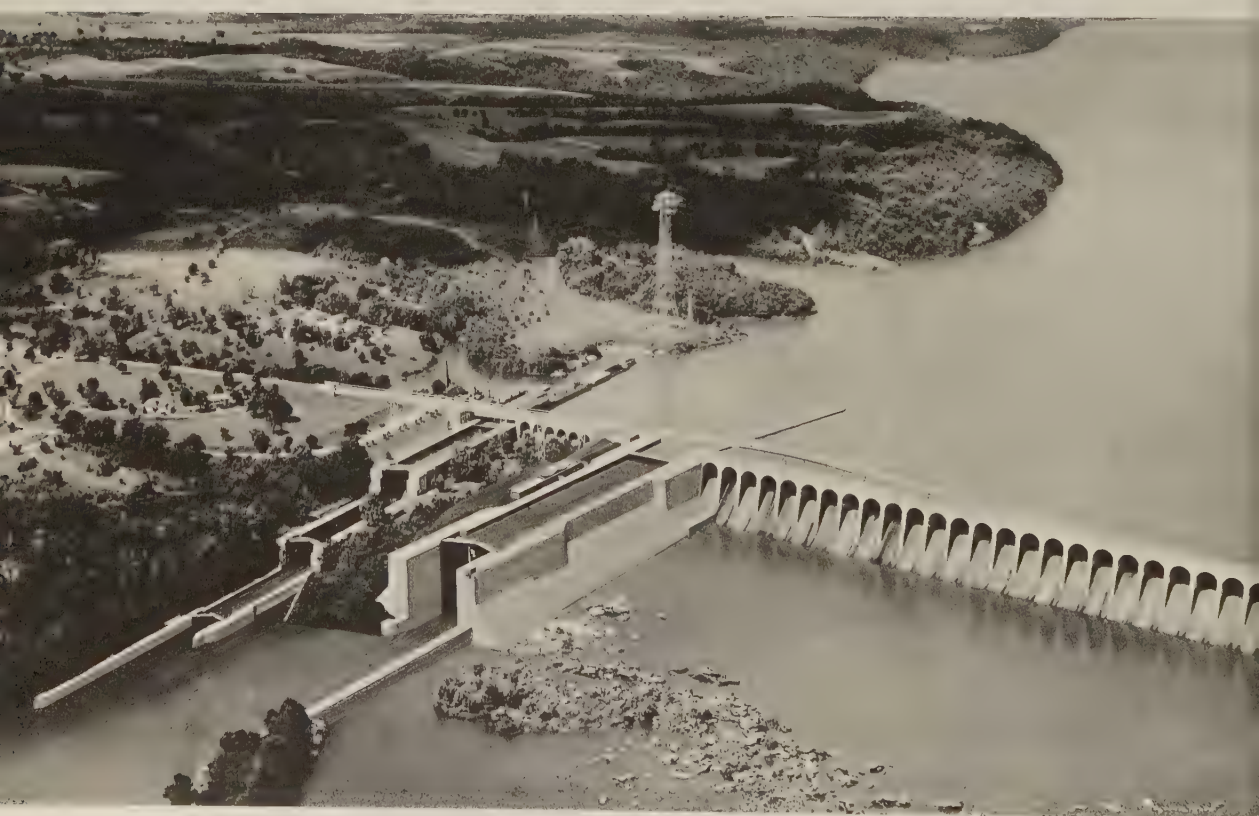
length	: 4,535 ft.
maximum height	: 137 ft.
construction started	: april 14, 1918
construction completed	: september 12, 1925
generating capacity	: 436,000 kw
cost	: $52,000,000

To meet a pressing need for nitrates, from which explosives are made, Congress in 1916 authorized the War Department to build two nitrate plants and a large dam at Muscle Shoals. Construction of the dam was started by the Corps of Engineers in 1918 but was interrupted after the Armistice, when the need for nitrates seemed obviated. When the dam was finally completed, in 1925, it became the subject of national controversy until 1933, when Congress turned it over to TVA as part of the TVA Act. Since then, the nitrate plants have been used for research in munitions and in fertilizers for a nationwide program of fertilizer use and education. In 1951 a new chemical engineering building was completed to provide modern laboratories, supplementing the facilities of the two nitrate plants (see p. 9). The entire country has profited from TVA's fertilizer research.

The contrast between Wilson and even TVA's first dam, Norris, built only fifteen years later, is most striking. Today it is difficult to imagine how the classical revival in architecture managed to work its way into this type of industrial structure.

Compare this absurd and costly detail of Wilson Dam with the clean expressive forms of TVA-built dams. Here concrete, a plastic substance, has been made to imitate stone forms and to disguise the real structural material, which is steel.

The original locks at Wilson (*left*) will be supplemented by a single high lock (*below*) scheduled for completion in 1959. The generator room in the powerhouse contrasts sharply with the later TVA projects. The simpler, cleaner plants of TVA are not only more attractive but are also easier and cheaper to maintain.



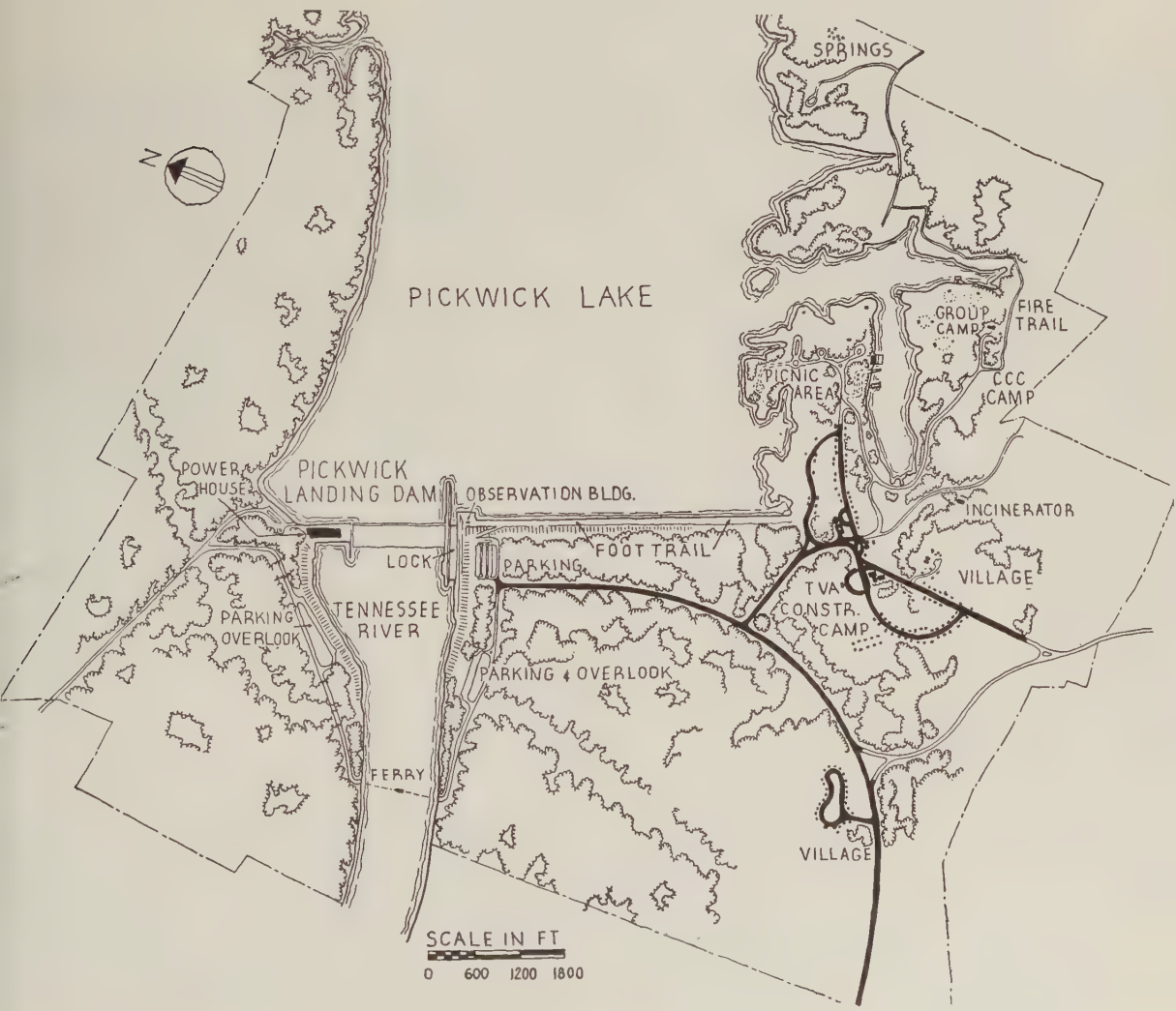
These generators at Wilson produce about the same amount of power each as those at Kentucky, but they require nearly twice as great a water head per kilowatt of capacity.

Five miles downstream from here is Pittsburg Landing, where 20,000 Americans lost their lives in the Battle of Shiloh, April 6 and 7, 1862.

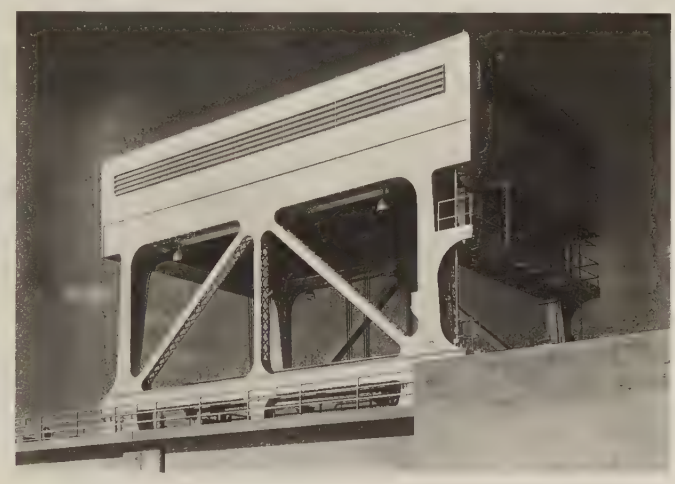
PICKWICK LANDING

length	7,715 ft.
maximum height	113 ft.
construction started	march 8, 1935
construction completed	june 29, 1938
generating capacity	216,000 kw
cost	$47,000,000

In addition to the lock, spillway, and powerhouse sections at Pickwick, there is approximately a mile of earth-and-rock dam. Just above the south end of the dam is a natural inlet, which was developed by TVA and the Civilian Conservation Corps into a recreation area with facilities for camping and boating. The construction camp, laid out before the dam was built, included many permanent buildings. The houses are now occupied by the families of men who operate and maintain the dam. TVA owns or controls nearly all of the hundreds of miles of shoreline around its many lakes. Since proper care of the lakes and dams is directly related to the use and care of the shore, TVA built pilot installations for recreation, which were turned over to the state.



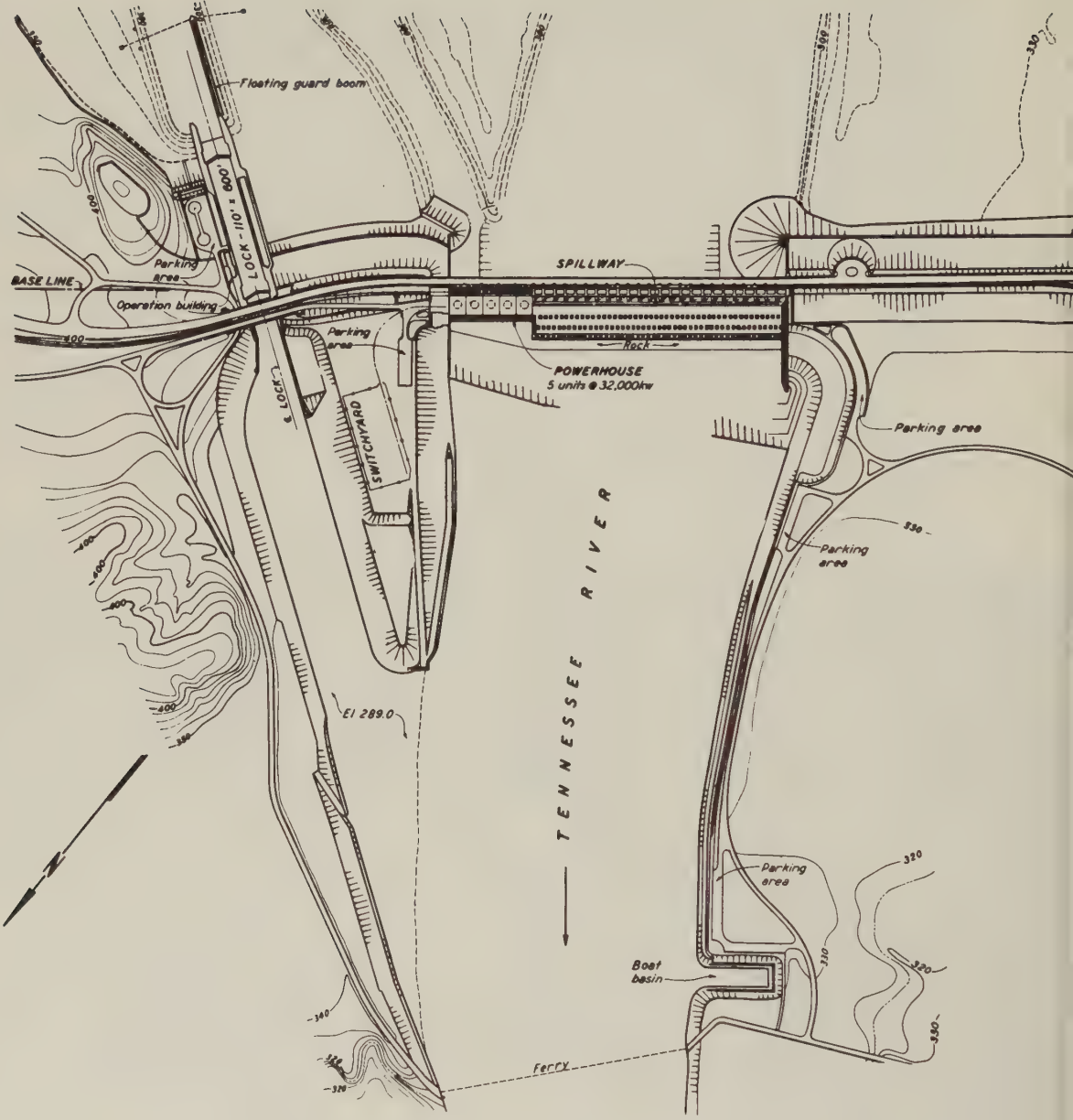
Pickwick is the only dam TVA designed with the switchyard atop the powerhouse. The generator room (*acrosspage*), gantry crane (*right*), and water level gauge (*below*) are typical of the excellent early work of TVA's architects and engineers. Designed before 1935, these details are still "modern" today.



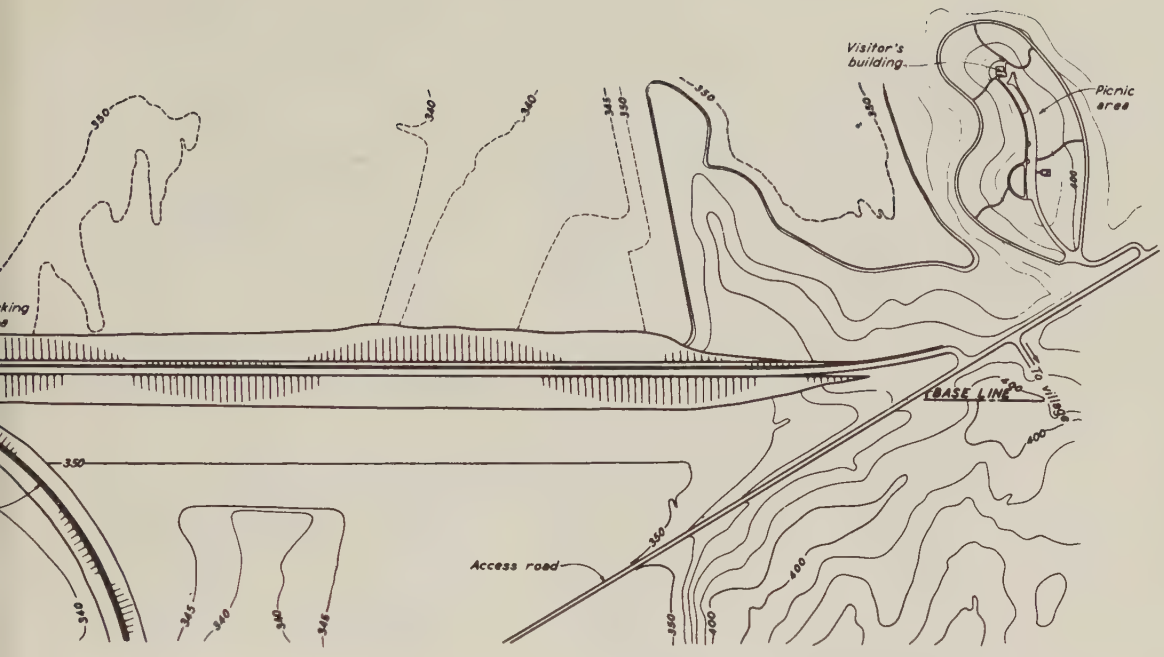
KENTUCKY

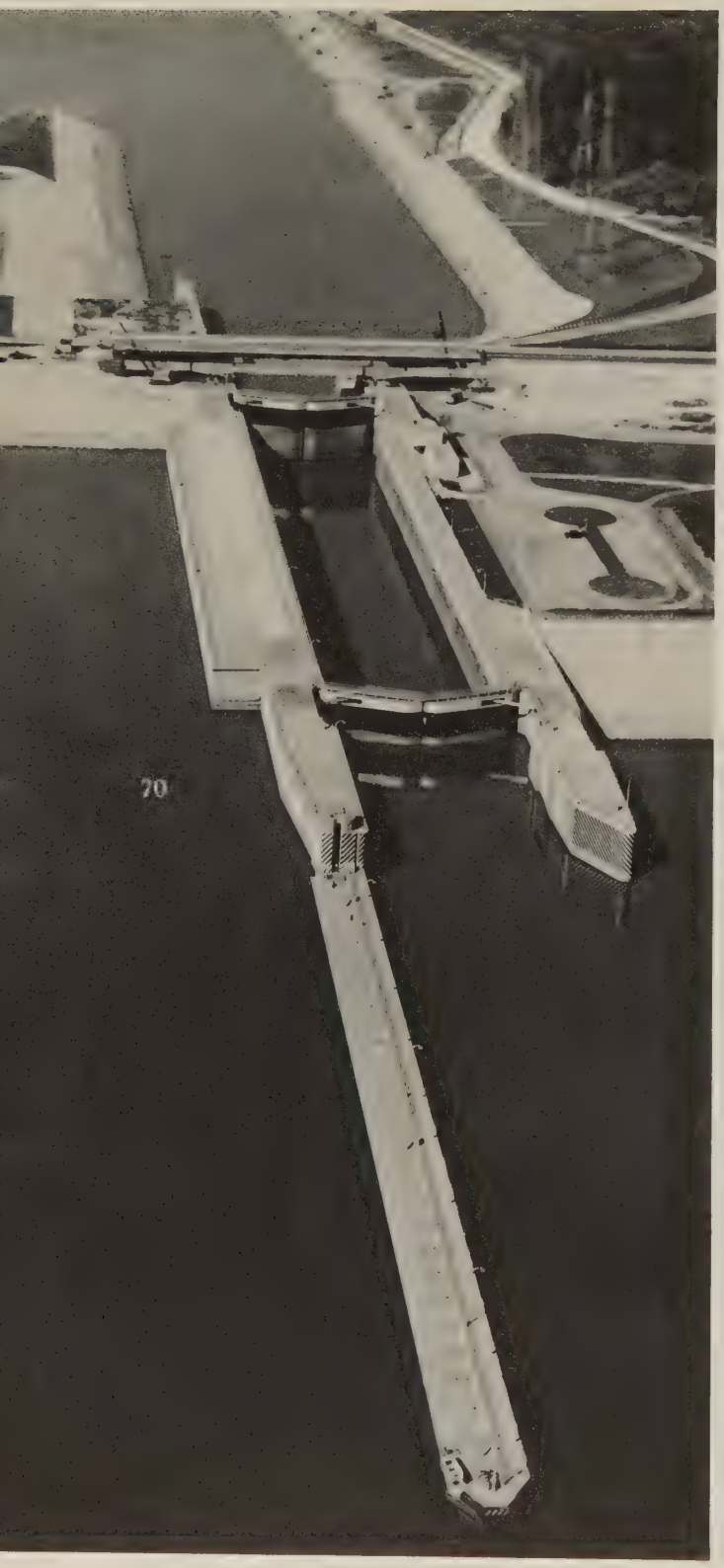
length	: 8,422 ft.
maximum height	: 206 ft.
construction started	: july 11, 1939
construction completed	: september 14, 1944
generating capacity	: 160,000 kw
cost	: $119,200,000

The greatest of all TVA dams—approximately 7 million cubic yards of concrete, earth, and rock—Kentucky Dam backs up water for 184 miles. The maximum water storage capacity of Kentucky Lake is more than twice that of the next largest lake, Norris; and it cost almost 50 per cent more than Fontana Dam, which is twice the height of Kentucky. To accommodate the large tows coming into the Tennessee from the Ohio River, the lock at Kentucky—like that at Pickwick—is about double the size (though not the height) of any lock above Pickwick except the new lock at Wilson Dam. The colossal gantry crane that serves the powerhouse is the largest ever built by TVA, and certainly one of the most attractive. Unlike any other TVA dam, Kentucky supports both a highway and a railroad. Both were built as part of TVA's relocation program.

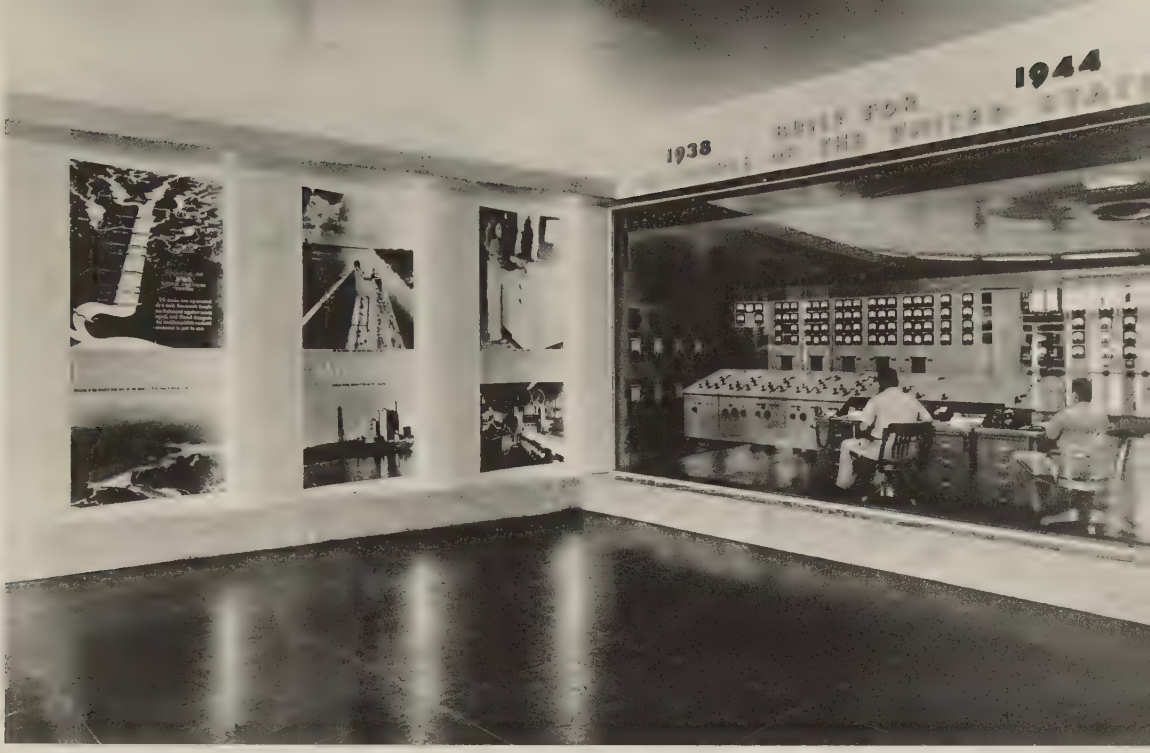


TVA relocated the Illinois Central Railway bridge that formerly crossed the Tennessee about where the switchyard is now. The old shoreline is shown above by a dash line; the lock and its approaches were cut through dry land. Notice the facilities for recreation: a boat basin (*above*); and the visitors' building and picnic area (*upper right*).


Visitor's building
Picnic area
BASE LINE
Access road
350
340
345
400



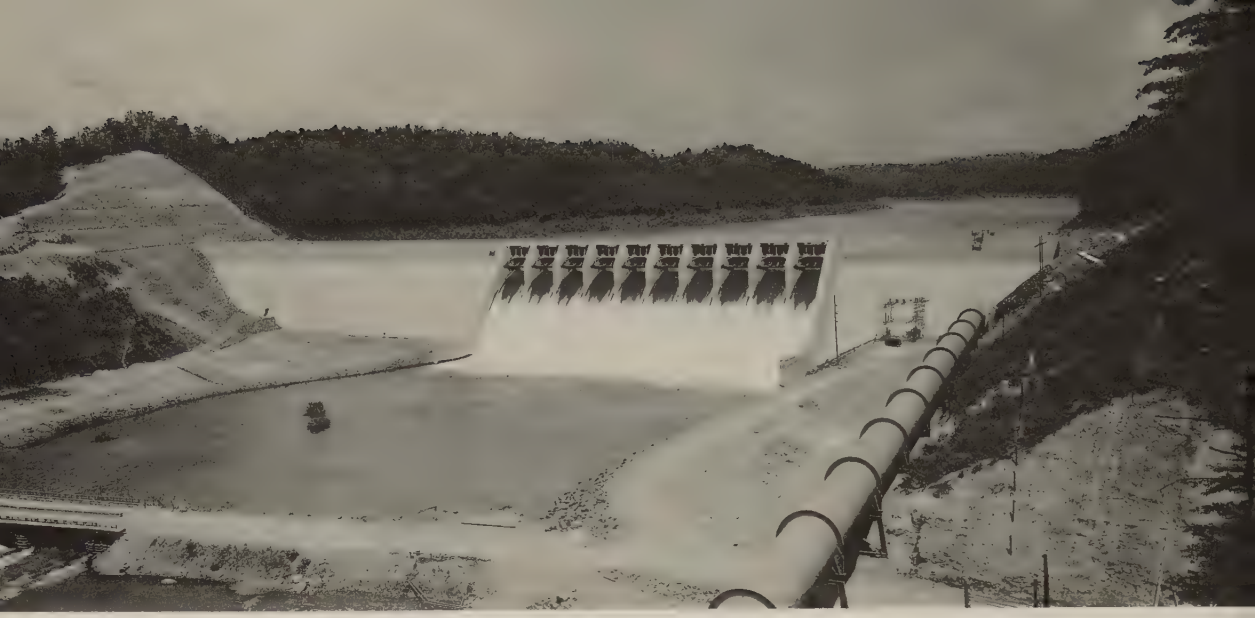
The floating guard wall in the foreground (*left*) was less expensive than earlier piers designed by TVA (see p. 42). From the lobby of the powerhouse the visitor can watch the control operations through a large plate glass wall (*across-page, top*). By elevator he can go down to the attractively tiled generator room.

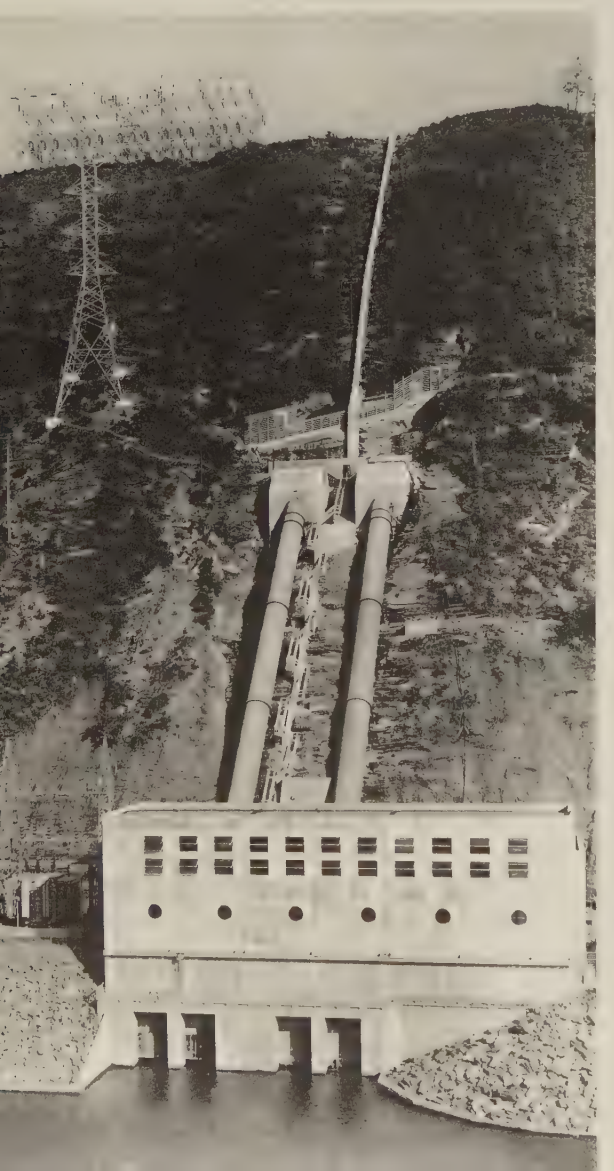

1938
1944

Storage Dams

CHAPTER IV

The dams on the tributaries of the Tennessee differ fundamentally from those on the main river both in function and in appearance. The greatest difference results from the fact that the tributaries are not important as navigable streams. Navigation locks, therefore, are not financially practicable. In addition, since the important tributaries are located mainly in the eastern mountains, their banks often rise sharply, eliminating the need for long earth-and-rock sections in most of the dams. One result of these combined factors is that the tributary dams tend to be higher and more dramatic than the lower, longer dams on the Tennessee. Often referred to as storage dams, their purpose is to level out the flow of the Tennessee by holding back water during certain seasons and releasing it later as it is needed downstream. In December and January the visitor will find them quite low, awaiting the winter rains, while in April and May he will usually find them nearly full, ready to supply water downstream during the dry summer months ahead. The area in the map below receives more annual rainfall than any other part of the country except the Pacific Northwest.





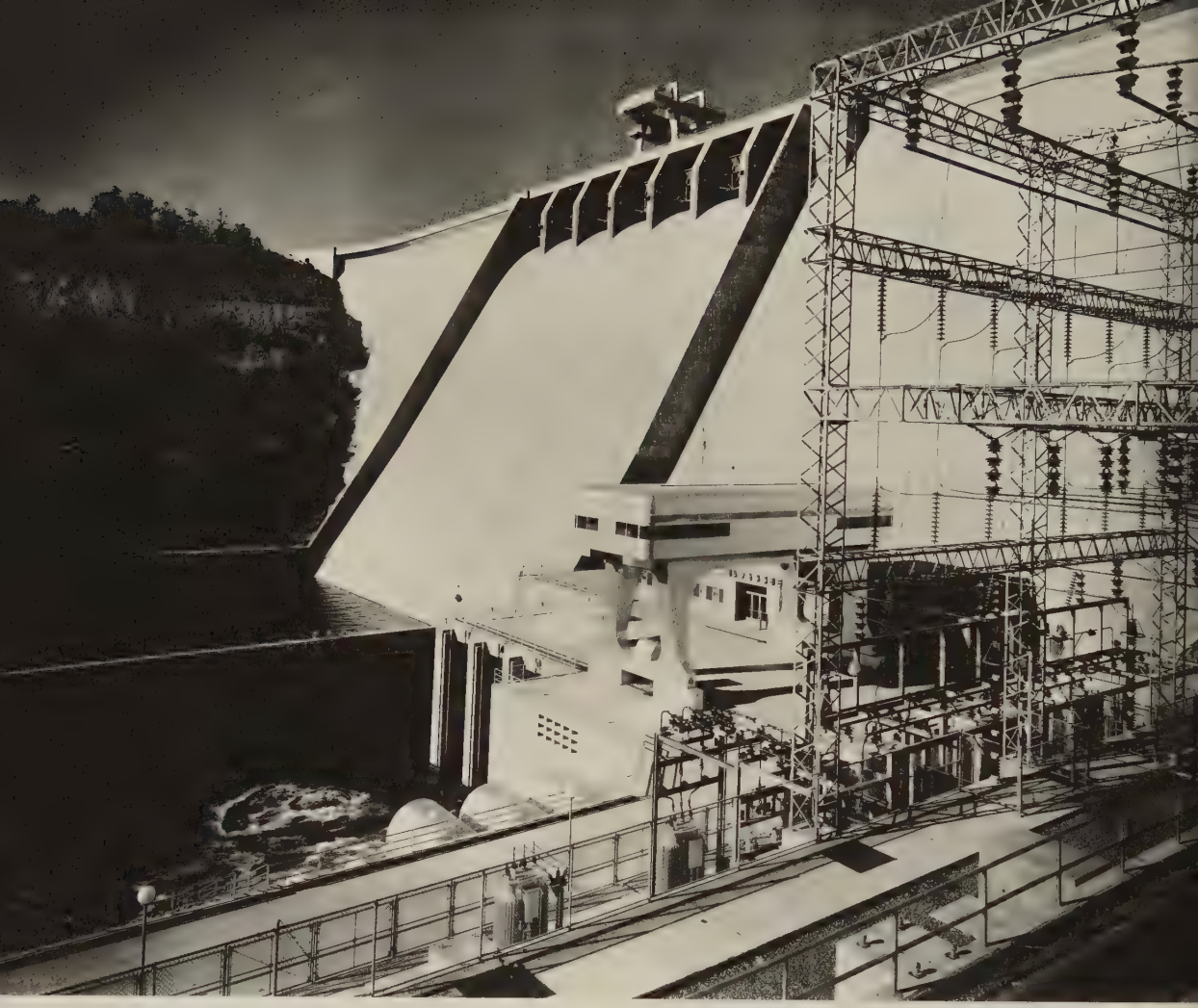
Although Apalachia is only 150 ft. high, the water head at the powerhouse is more than 400 ft. From the dam, water is conducted through a steel tube (*above*), 18 ft. in diameter, to a concrete-lined tunnel through the mountains. Just above the powerhouse, twin conduits receive the water and feed it into the two turbines. The surge tank is a concrete well, 66 ft. in diameter, dug into the top of the mountain near the switchyard. (The small electrical duct at the top of the mountain is not the water conduit, which is underground at that level.)

APALACHIA

length	: 1,308 ft.
maximum height	: 150 ft.
construction started	: july 17, 1941
construction completed	: september 22, 1943
generating capacity	: 75,000 kw
cost	: $23,700,000

In the Hiwassee River Basin are three rivers: Hiwassee, Ocoee, and Nottely. Between 1936 and 1943 TVA built five dams in this area and acquired three others from the Tennessee Electric Power Company, Ocoee No. 1, Ocoee No. 2, and Blue Ridge, all built before 1933. Apalachia Dam was authorized by Congress in 1941, at the same time that Chatuge, Nottely, and Ocoee No. 3 dams were authorized. Although investigation of its site had begun as early as 1934, it was not until the outbreak of World War II that Apalachia was actually scheduled for construction. This dam is situated ten miles below Hiwassee Dam, at what was judged to be its best location, though the Hiwassee River drops very gradually over this stretch. To get a greater head of water at the powerhouse it was decided to locate the powerhouse not at the dam but at a place eight miles farther down the river and to bring water to it by conduits. By this means, full advantage was taken of the rapid descent over this part of the river.

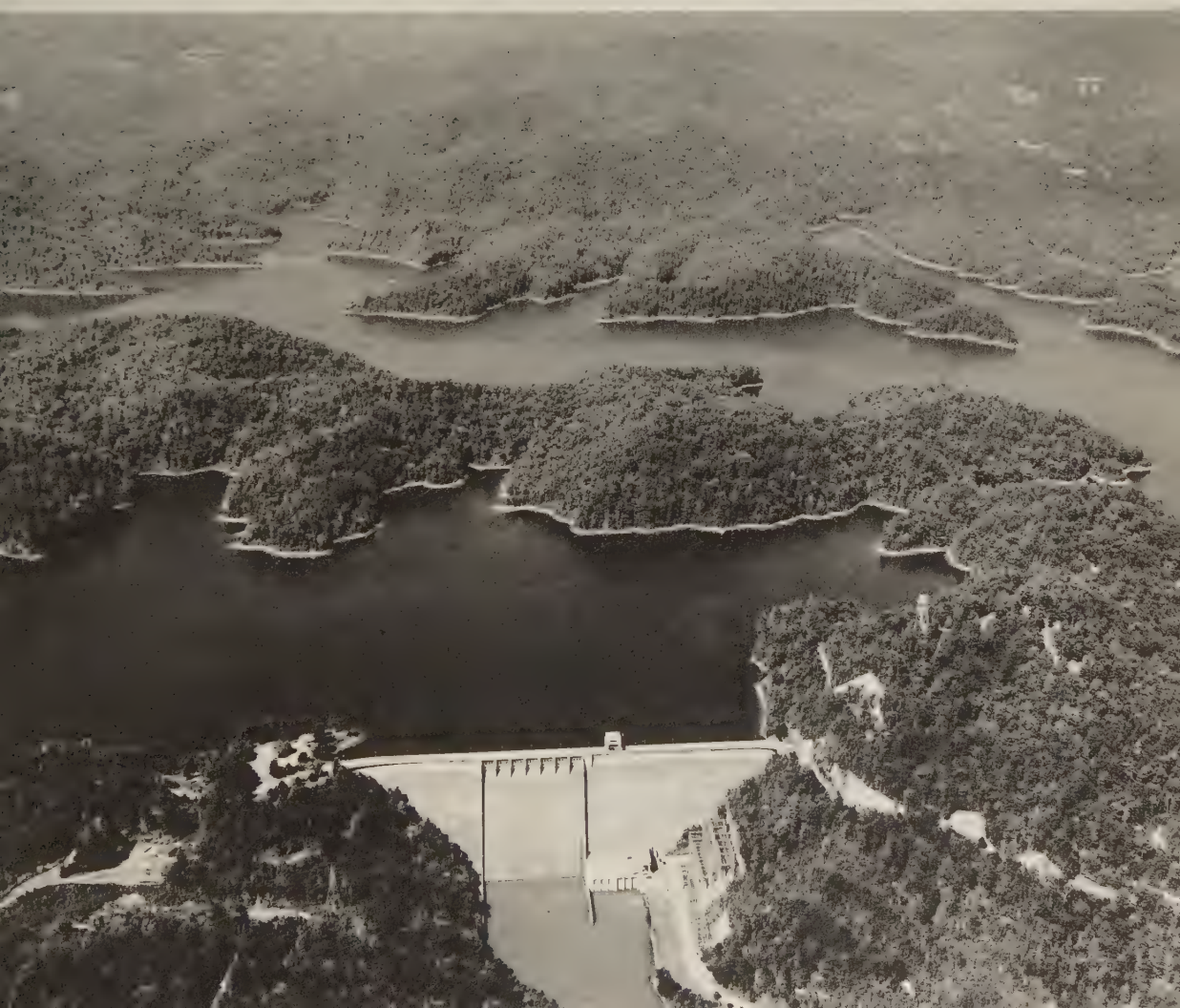
Near Apalachia Dam, TVA built houses and community buildings for personnel. At left is the recreation building. Below is a typical house. Twenty years old, they are still considered good design.



HIWASSEE

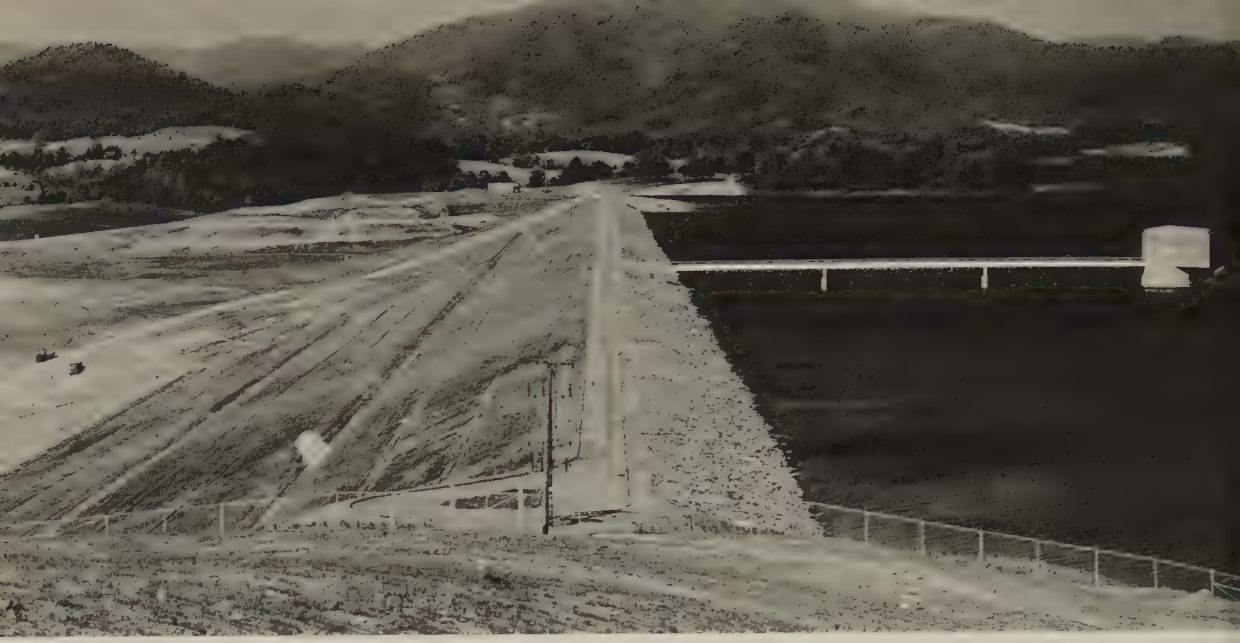
length	1,376 ft.
maximum height	307 ft.
construction started	july 13, 1937
construction completed	may 21, 1940
generating capacity	117,100 kw
cost	$23,200,000

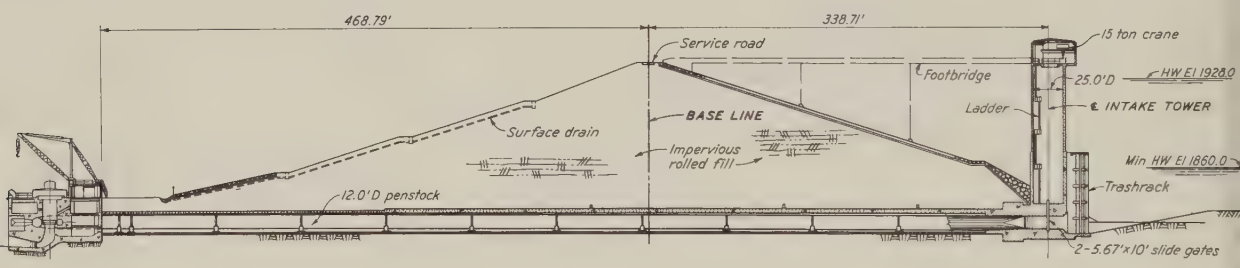
Primarily a storage dam, Hiwassee was built with only one generator installed. By 1956, the second unit was installed, but this one differed from the first in that it was a pump-turbine—that is, both a turbine and a pump. During periods of low power consumption the turbine can be reversed to pump water back into the reservoir for use during periods of high power consumption. TVA's power and flood control system is so delicately balanced that just a few million gallons of water can at times become very important. Of special interest at Hiwassee are the two striking gantry cranes, each different from any other in the TVA system.



At the northwest end of the dam, overlooking Hiwassee Lake, is the visitors' observation platform (*above* and *acrosspage*). The road across the top of the dam is narrow, but parking is provided at both ends, and the visitor may walk across if he wishes.

Hiwassee is considered by many people to be the most beautiful dam built by TVA. However, because it is not as accessible as other dams, it is not as frequently visited.

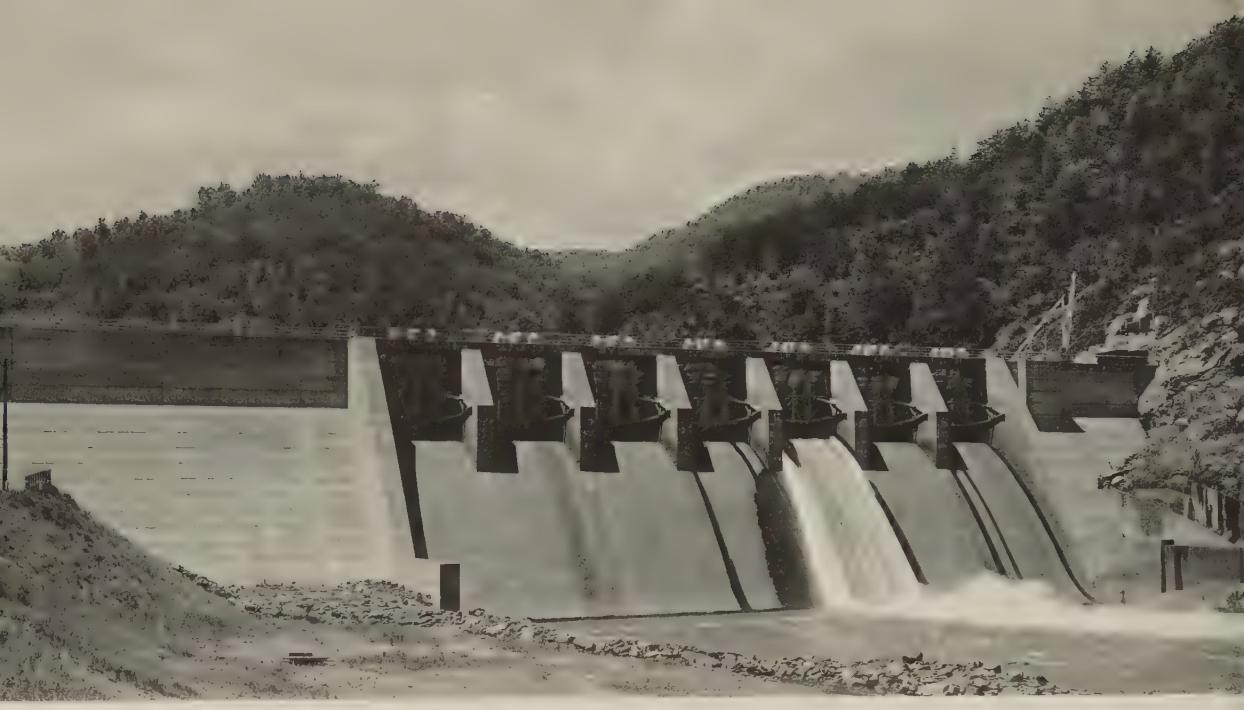


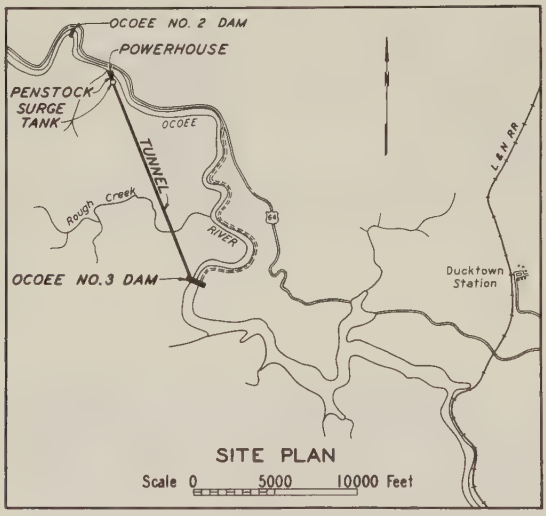


CHATUGE

length : 2,850 ft.
maximum height : 144 ft.
construction started : july 17, 1941
construction completed : february 12, 1942
powerhouse constructed : 1952–54
generating capacity : 10,000 kw
cost : $10,000,000

Chatuge is the only TVA-built dam composed entirely of rolled earth. Preliminary design studies showed that earth, faced with rock rip-rap on the upstream side, would make an adequate dam here, and at a much lower cost than a concrete dam. Flashboards at the top of the spillway (*above*) add several additional feet to the effective height of the dam. A single-unit powerhouse, completed in 1954, is located at the downstream foot of the dam, some eight hundred feet from the intake tower. The aerial photograph below shows the disposition of elements: spillway to the left; intake tower and powerhouse near the right.

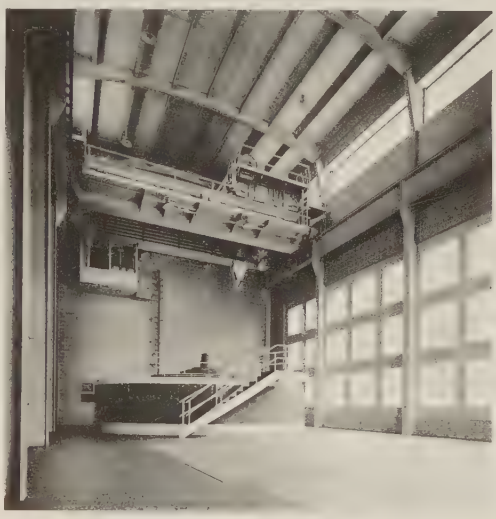




OCOEE NO. 3

length : 612 ft.
maximum height : 110 ft.
construction started : july 17, 1941
construction completed : april 30, 1943
generating capacity : 27,000 kw
cost : $8,700,000

A sister project to Apalachia Dam, Ocoee No. 3 was begun on the same day as Apalachia, Chatuge, and Nottely. As at Apalachia, the most favorable site for Ocoee No. 3 was not the most advantageous for a powerhouse. An additional water head of 270 feet was gained by putting the powerhouse downstream about 2.5 miles. Since the powerhouse (*below*) is operated remotely—from Ocoee No. 2 (purchased by TVA from the Tennessee Electric Power Company)—no permanent personnel is required. Also, the seven radial spillway gates at the dam are remotely controlled; hence, there are no facilities for visitors either at the powerhouse or at the dam.



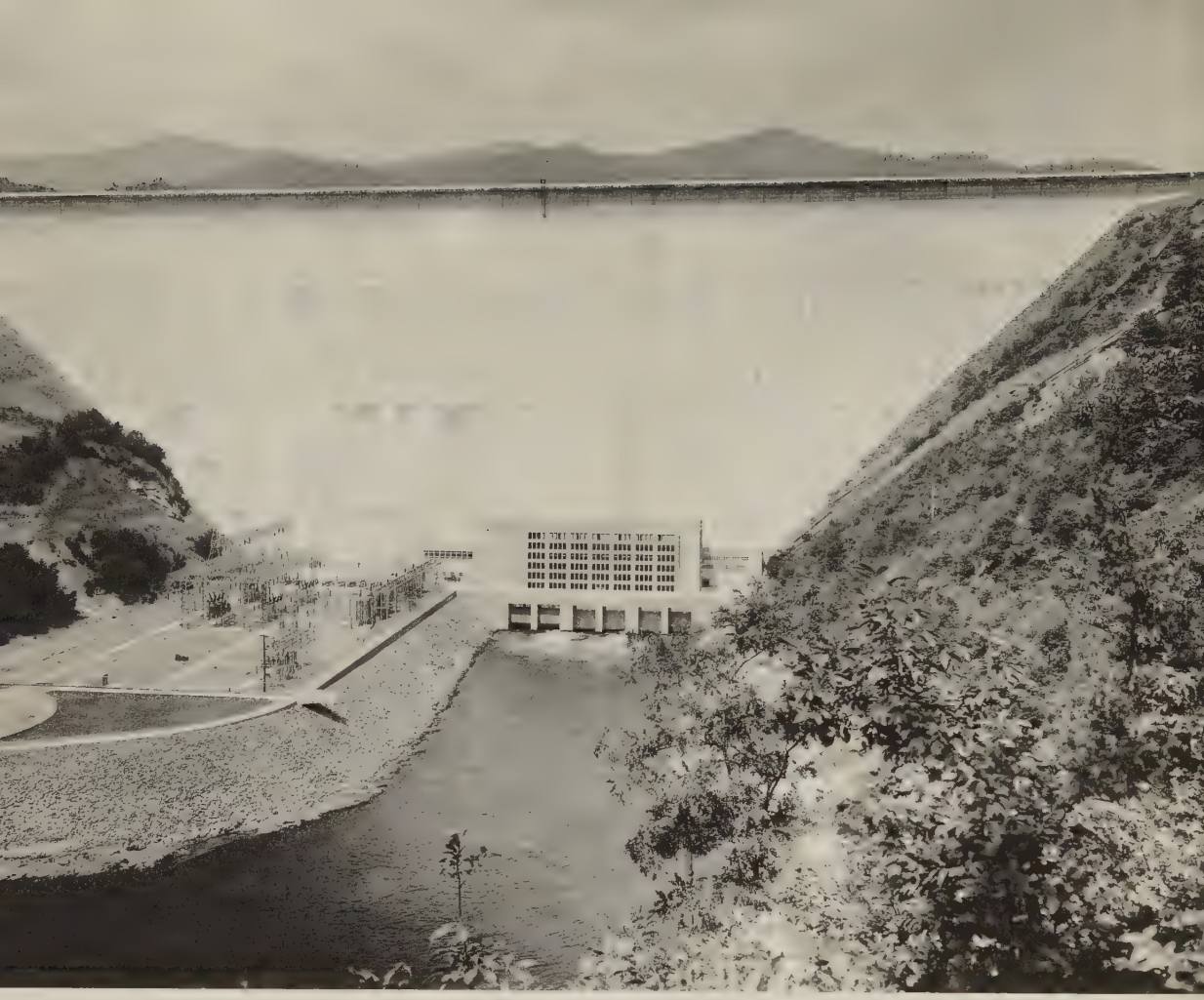
At right is the interior of the powerhouse. What appears to be an observation booth against the wall is actually a control cab suspended from the ceiling crane.

The pyramidal mound of earth at left, which forms half of the dam, is 720 ft. thick at the bottom. The impervious earth core is reinforced on both sides by thick layers of rock.

NOTTELY

length	2,300 ft.
maximum height	184 ft.
construction started	july 17, 1941
construction completed	january 24, 1942
powerhouse constructed	1952–55
generating capacity	15,000 kw
cost	$8,600,000

The fifth and last dam built by TVA in the Hiwassee River Basin is Nottely. Similar to Chatuge in conception, it has a core of rolled earth; but thick shoulders of rock were added for stability. As at Chatuge, most of the water discharged from Nottely Lake passes through the underground penstock to the turbine. A low bridge spans the crest of the spillway, and a road traverses the full length of the dam.

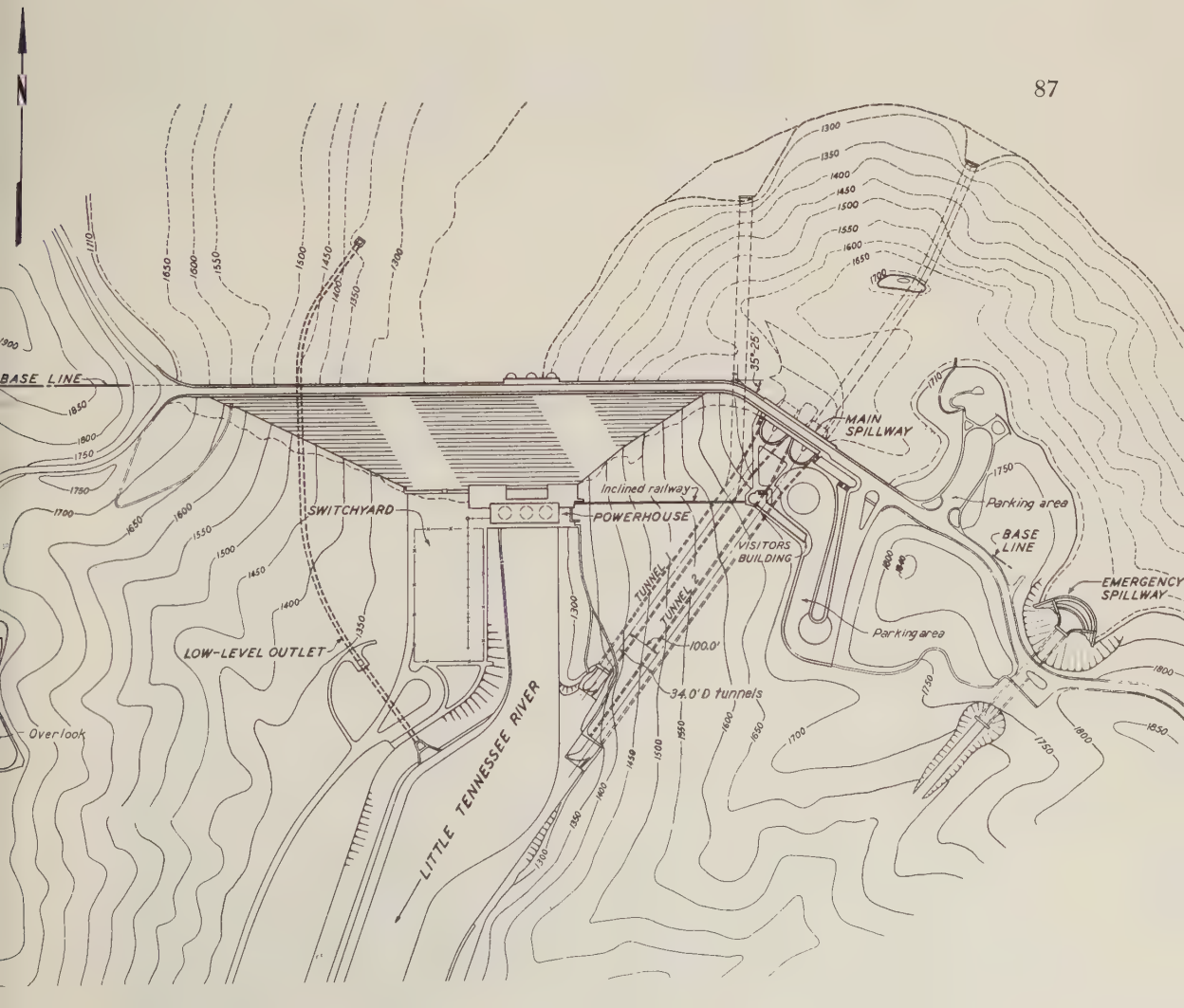


FONTANA

length	: 2,365 ft.
maximum height	: 480 ft.
construction started	: january 1, 1942
construction completed	: january 20, 1945
generating capacity	: 202,500 kw
cost	: $75,800,000

The most dramatic of all TVA dams and the highest dam in the United States east of the Rocky Mountains, Fontana was begun on the Little Tennessee River less than a month after the Japanese attack on Pearl Harbor and our entry into World War II. Whereas most of the dams on the main river were built when there was an abundance of labor, materials, and time, Fontana was begun and completed during a time of severe wartime shortage of all three elements. By 1942, however, TVA had developed an efficient, highly skilled design and construction force, which was able to meet and overcome these obstacles. In just three years this team built a dam that ranks among the most beautiful in the world.

In addition to the dam itself, this project resulted in many secondary achievements of excellence, particularly in village planning and construction and in bridge building. Fontana is today a popular resort, visited by thousands of people every year.



To conserve time and materials, it was decided to omit an elevator at Fontana. This, plus the fact that no water spills over the top of the dam, left the top of the dam a straight unbroken line, accentuating its length. An inclined railway was laid to connect the powerhouse with the visitors' building (*above*), though a car is yet to be installed. Outlets for the spillway can be seen below in the lower right corner.

The very bold, seemingly oversized columns and beams inside the powerhouse (*below*) solved two important problems for TVA designers: the shortage of structural steel; and the problem of relating a normal-sized powerhouse to an abnormally large dam. To offset a possible oppressiveness in these heavy concrete members, large glass windows were used to honeycomb three sides of the powerhouse, flooding it with light.

90

Though much of the Fontana construction village consisted of temporary and prefabricated buildings, part of it was to remain as a permanent village. Among the permanent structures was the school (*above*). Many of the attractive prefabs (*below*) developed by TVA were used at Oak Ridge. The village is today leased to Government Services, Inc., and is operated as a resort.

The Tennessee-North Carolina border follows the peaks of the Great Smoky Mountains that rise up behind Fontana, which is in North Carolina. An average of 75–80 inches of rain falls on the Fontana watershed each year.

CHEROKEE

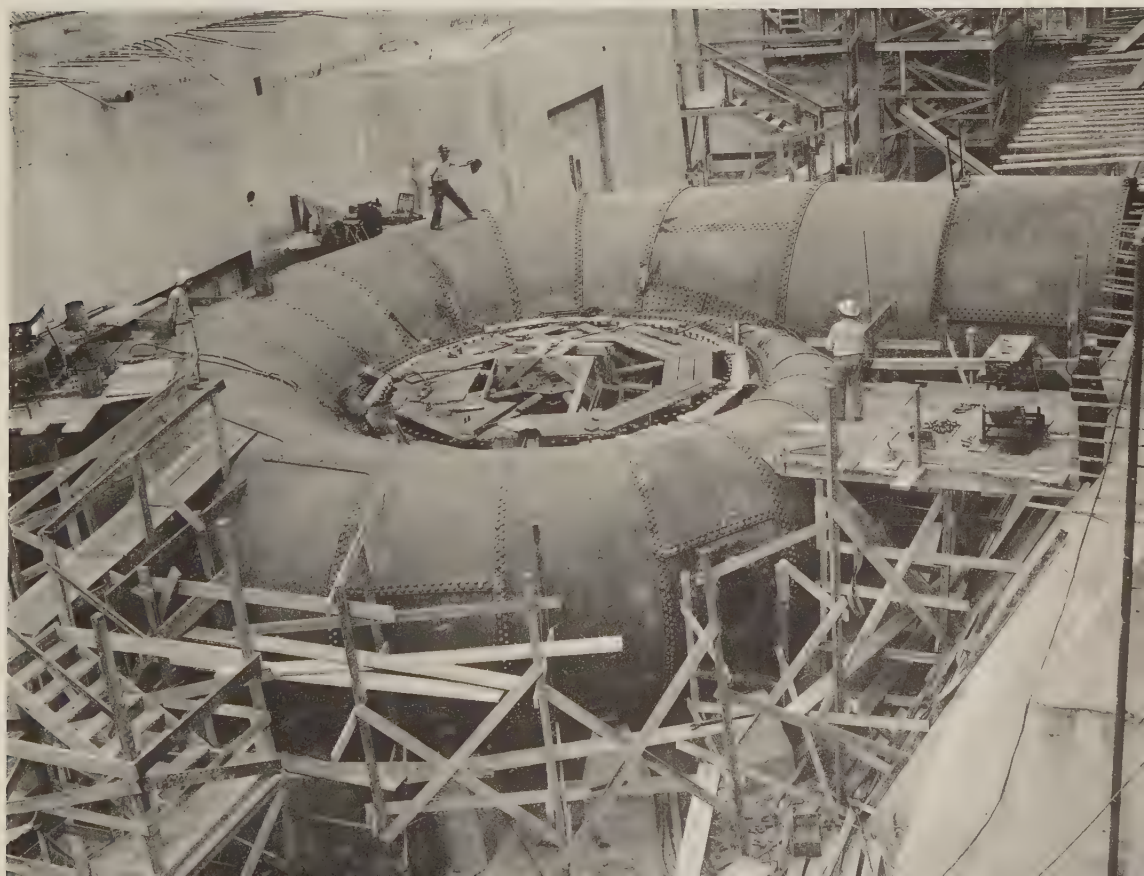
length	: 6,760 ft.
maximum height	: 175 ft.
construction started	: august 1, 1940
construction completed	: april 16, 1942
generating capacity	: 120,000 kw
cost	: $36,300,000

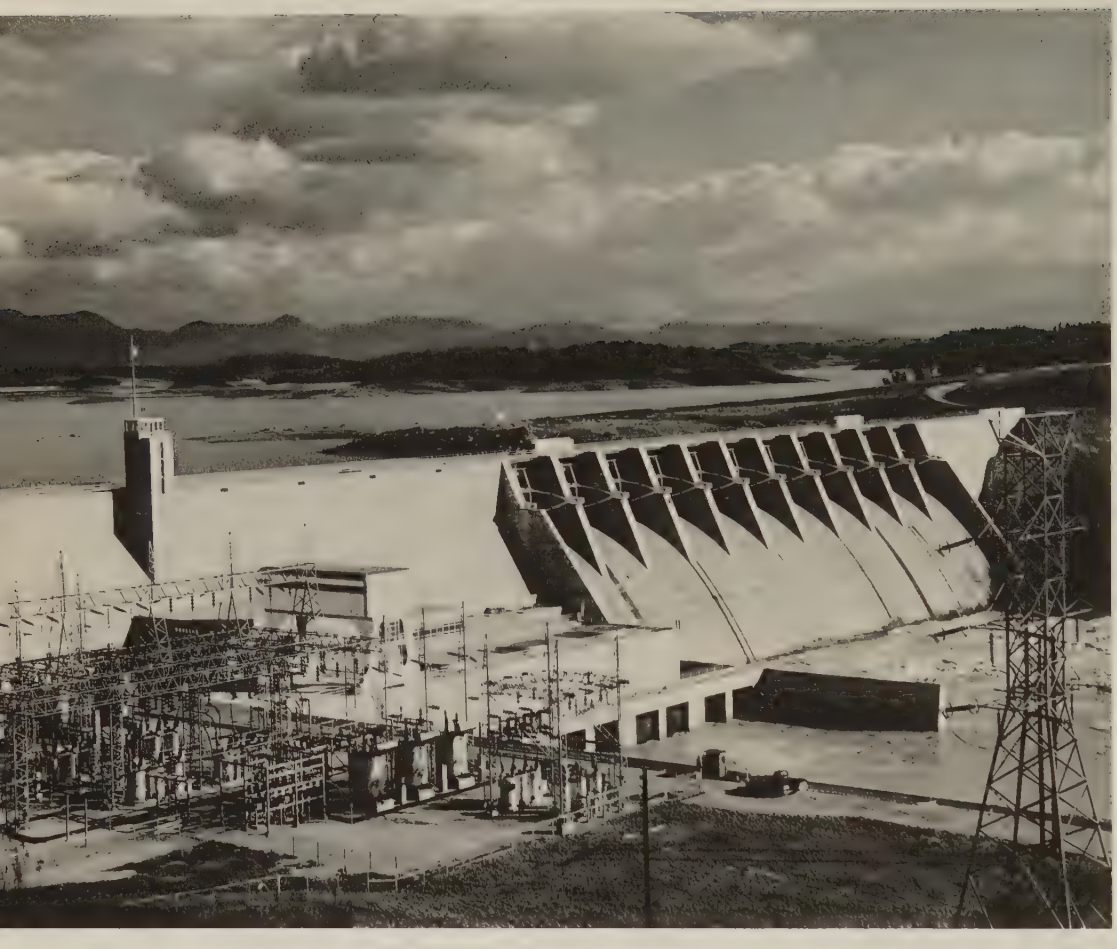
After war had broken out in Europe and America had begun to mobilize her defenses, TVA was asked by the War Department to survey the valley's supply of and future demand for power for defense industries. Despite the completion of six hydroelectric projects in seven years, the survey predicted a dangerous power shortage by 1942, even with the completion of the dam and steam plant at Watts Bar. The order was given to begin a dam on the Holston River forty miles above Knoxville and to have it in operation in twenty-one months, then the shortest schedule ever planned by TVA for such a project. Within sixteen months—two days before Pearl Harbor—the gates of Cherokee were closed, and impoundment of water began. In the middle of the twenty-first month, two weeks ahead of schedule, the first generator was producing power—not for defense plants now, but for war industries.

To meet a tight building schedule, TVA designers adapted many details for Cherokee from other dams. The top of the spillway, for example, was taken from Watts Bar, not yet finished in 1940.

Cherokee is the longest of TVA's tributary river dams. The observation tower (*above*) adds much visual interest to what might have been a monotonous expanse of concrete. The gantry crane is an almost exact duplicate of the one at Watts Bar. At left is a view of the upstream face of the dam during construction. Four trashracks screen dangerous debris from the water before it goes into the penstocks.

The giant turbine runner (*right*) is fitted into the center of one of the four scroll cases (*below*). The scroll case will be covered with concrete, and a large, perfectly machined steel shaft will connect the turbine runner to the generator, soon to be installed directly above the scroll case.



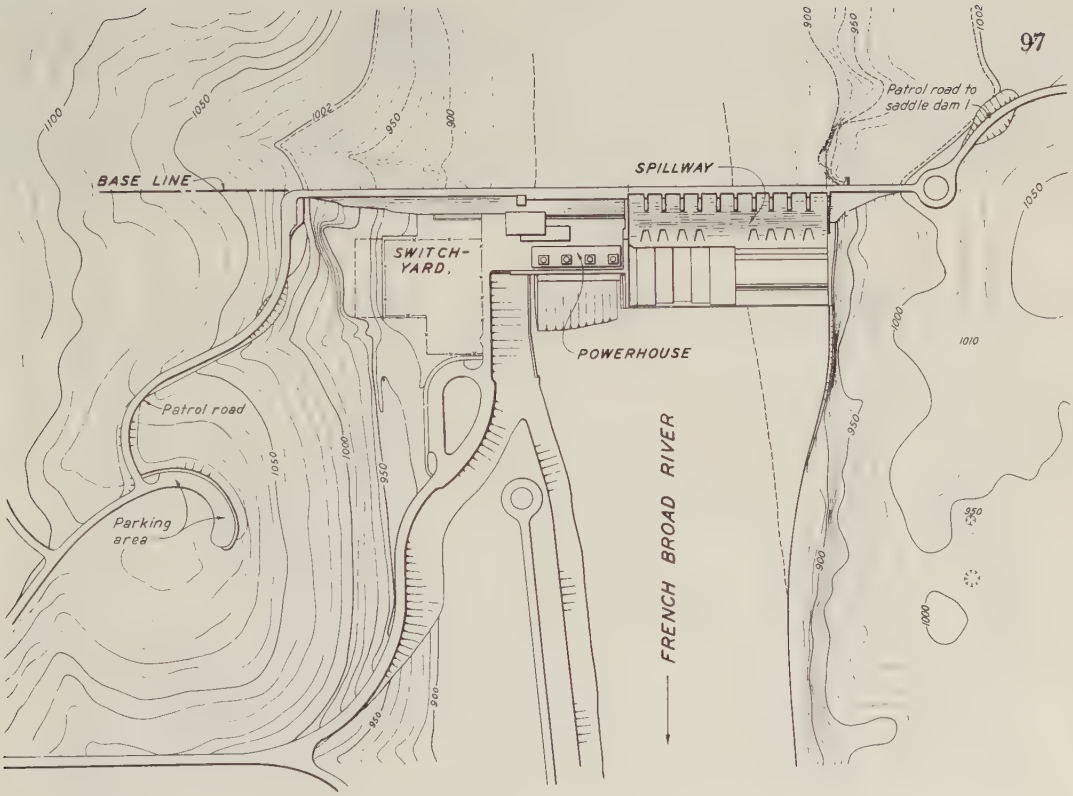


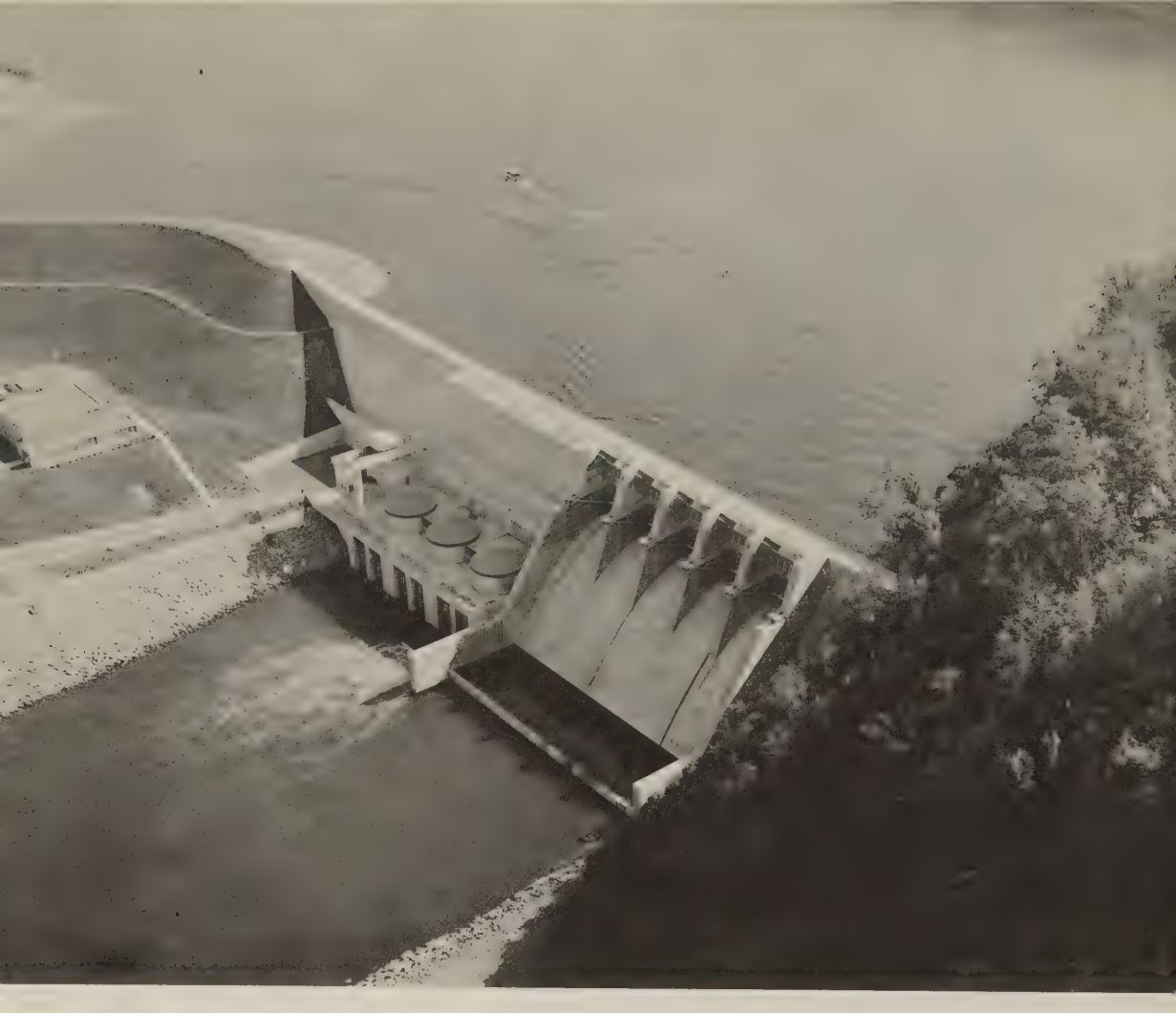
A wartime project, Douglas was impounding water and producing electricity only 13½ months after groundbreaking began—an incredible record of speed in such heavy and complex construction.

DOUGLAS

length	1,705 ft.
maximum height	202 ft.
construction started	february 2, 1942
construction completed	march 21, 1943
generating capacity	112,000 kw
cost	$46,200,000

Shortly before Pearl Harbor, when a proposal was made for a dam across the French Broad River—the Douglas project—Congress tabled it. However, in January, 1942, the project was again reviewed and passed by Congress, for it had been shown that here was the quickest way by which TVA could increase its power output. Cherokee Dam, only twenty miles away, was nearing completion, and the site at Douglas was very similar to that at Cherokee. Hence, by moving the labor force and heavy equipment just a few miles, and by using virtually the same blueprints as those used at Cherokee (with slightly different dimensions), TVA was able to build a dam in record time to reinforce its increasingly taxed power capacity and to reduce flood crests at Chattanooga by several feet.

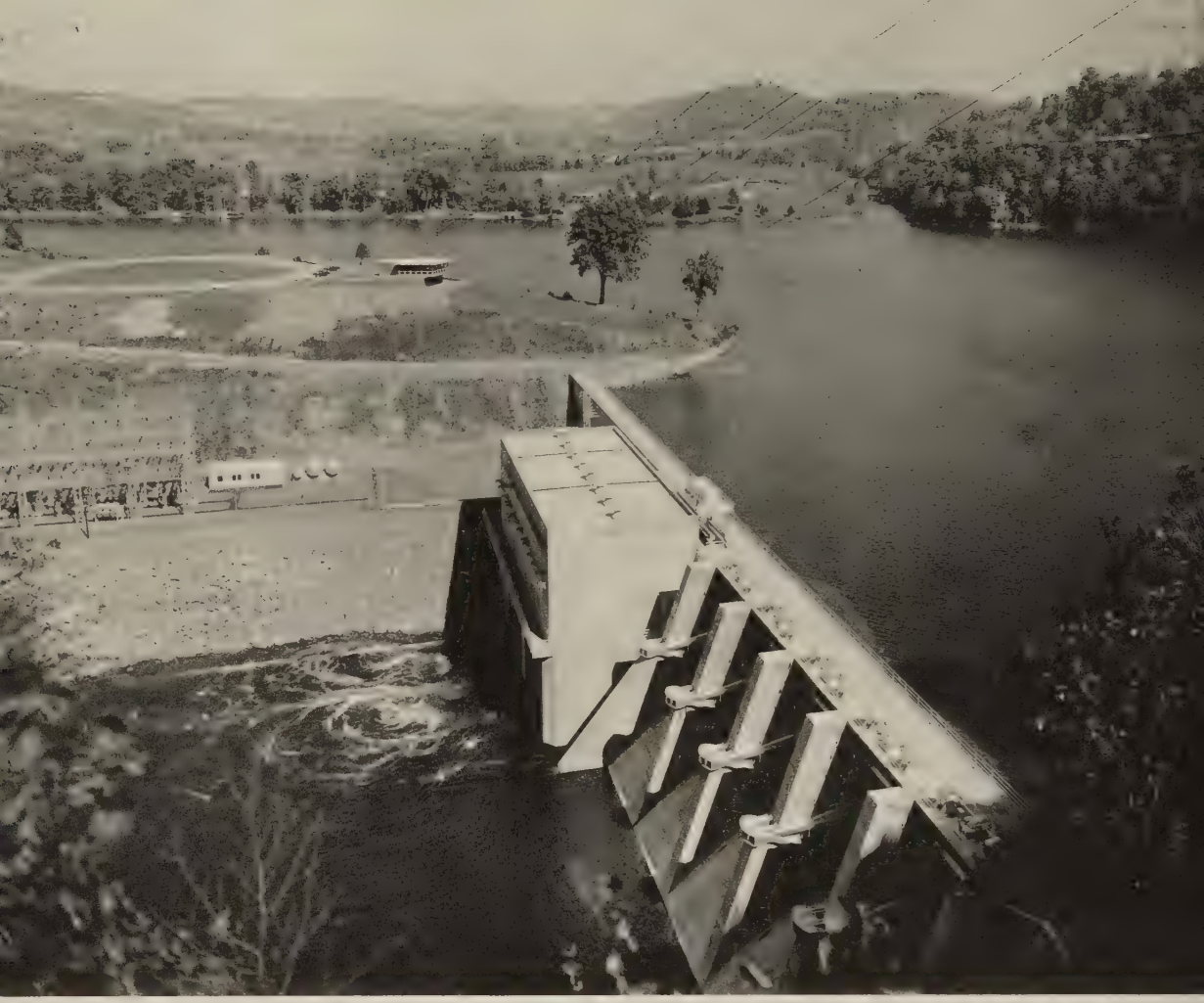




BOONE

length	1,532 ft.
maximum height	160 ft.
construction started	august 29, 1950
construction completed	march 16, 1953
generating capacity	75,000 kw
cost	$27,100,000

Boone was TVA's nineteenth dam in nineteen years of construction. Located between Fort Patrick Henry and South Holston dams, on the South Fork of the Holston River, Boone added 196,700 acre-feet of impounded water to the TVA system of lakes. The control building (*below*) is representative of TVA design in recent years. The reinforced concrete structural frame is perfectly expressed, while the bays between columns are curtained with brick and glass. As in most TVA projects, its beauty lies largely in its simplicity of form and detail. Of special interest here and at Fort Patrick Henry Dam are the beautiful murals depicting historical themes.

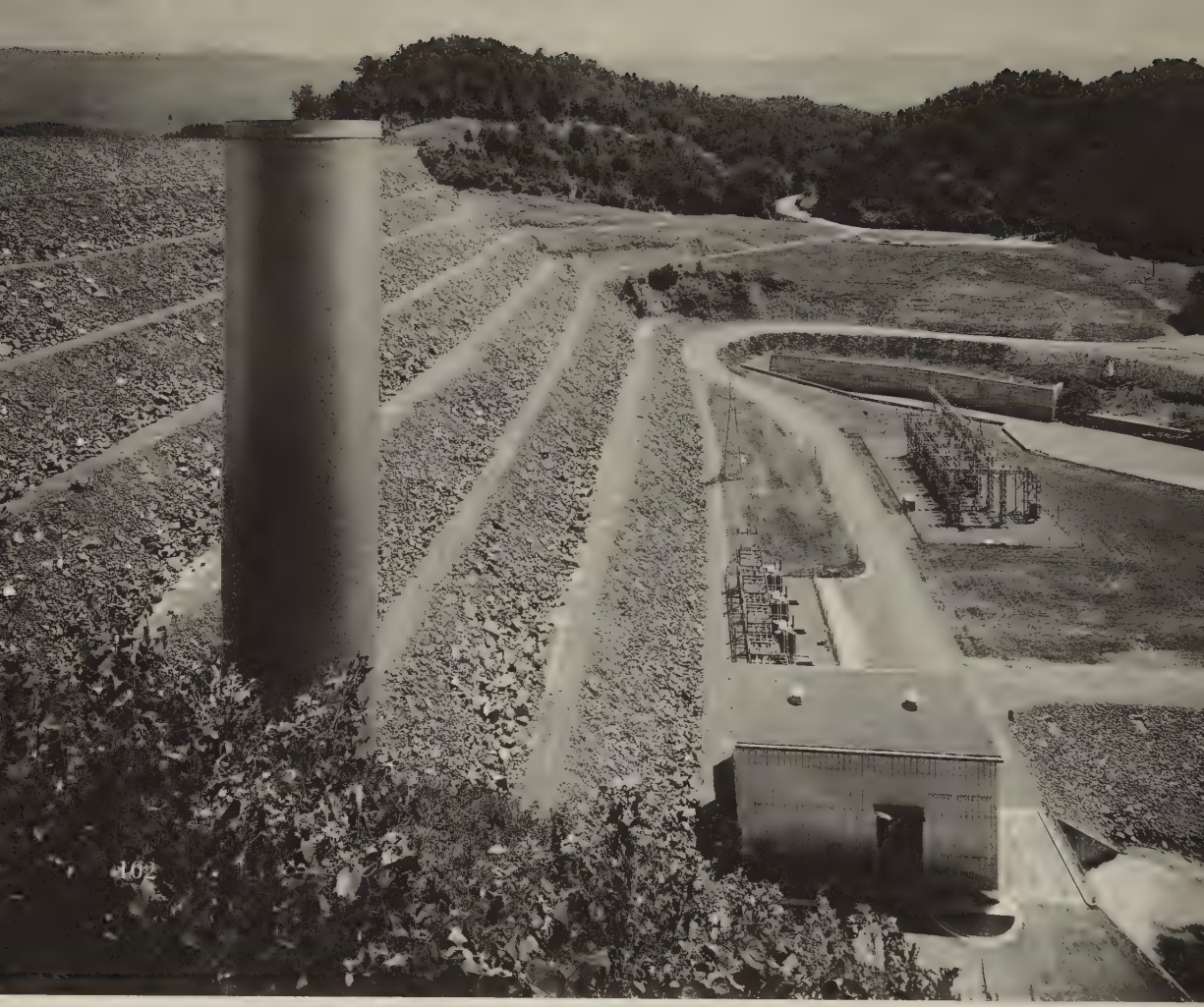


TVA's twentieth dam in twenty years was completed in 1953.

FORT PATRICK HENRY

length	737 ft.
maximum height	95 ft.
construction started	may 14, 1951
construction completed	december 5, 1953
generating capacity	36,000 kw
cost	$13,100,000

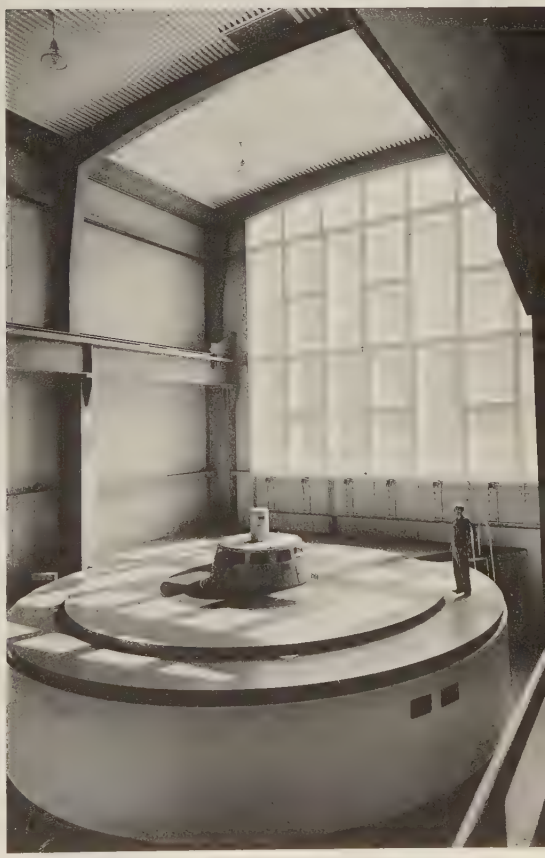
Located scarcely a mile from the city limits of Kingsport, Tennessee, Fort Patrick Henry Dam is closely related to Boone Dam in many ways. Not only are the two sites—at bends of the South Fork Holston—similar but this dam is remotely controlled from Boone. Since the visitors' building (*bottom*) has no maintenance or control function, it was built high on the bank, where it offers good views of both the dam and the reservoir. The area around the lake has become very popular as a residential suburb of Kingsport.



SOUTH HOLSTON

length	1,600 ft.
maximum height	285 ft.
construction started	august 4, 1947
construction completed	february 13, 1951
generating capacity	35,000 kw
cost	$31,200,000

Seven miles south of Bristol, Tennessee-Virginia, is TVA's third dam on the South Fork Holston. Although it was actually begun in February, 1942, construction had not advanced far when, in 1943, it was suspended in order to conserve critical war materials. Built of rolled earth and rock, South Holston is similar to Nottely Dam, in the Hiwassee River Basin. The two means of releasing water are apparent at left: through the turbine in the powerhouse; and through the underground spillway to the stilling basin just beyond the switchyard.



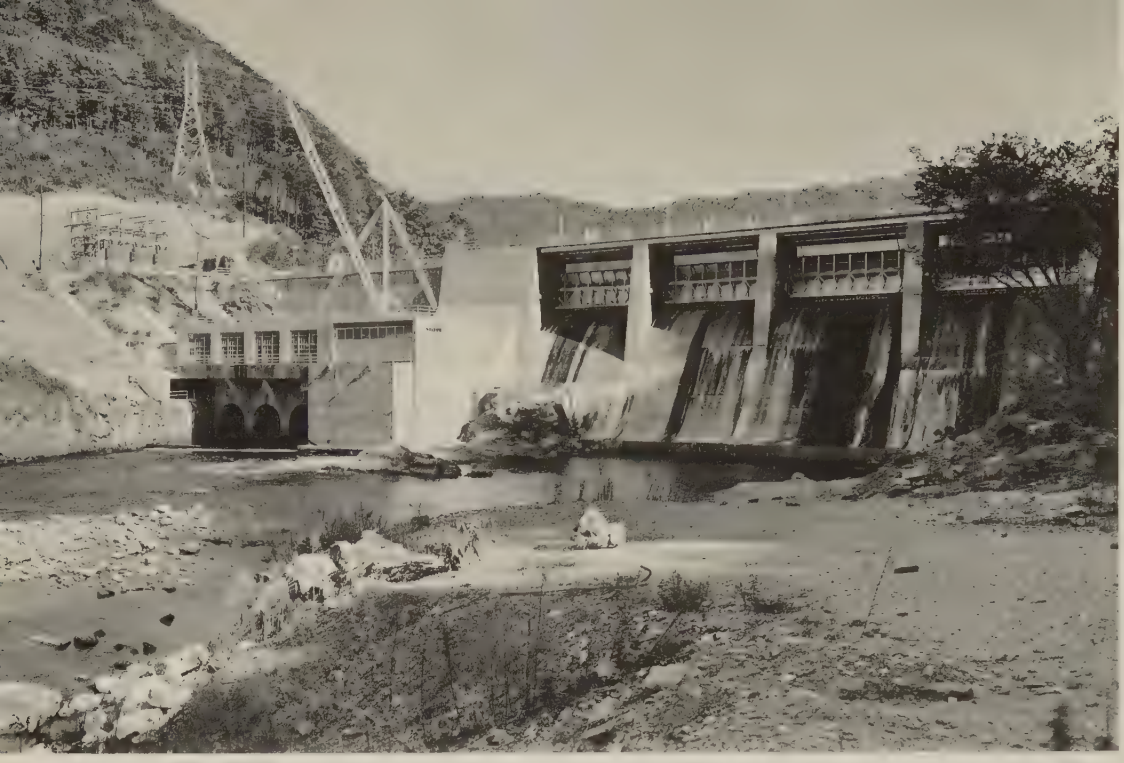
For economy of construction and maintenance, aluminum panels were used to cover the structural steel frame of the powerhouse. The large door at the side belies the actual size of the powerhouse. The dam is TVA's fourth highest.

WATAUGA

length	900 ft.
maximum height	318 ft.
construction started	july 22, 1946
construction completed	august 30, 1949
generating capacity	50,000 kw
cost	$32,300,000

A deep, narrow mountain gorge was filled with 3.5 million cubic yards of earth and rock to make Watauga Dam. First started in 1942, but discontinued because of the war, work was resumed in 1946 and completed three years later. For the sightseer, Watauga consists of three separate elements: the dam (*acrosspage*); the powerhouse and control building (*above*), one mile below the dam; and the visitors' building (*below*), which is a few hundred yards above the dam (a mile or more by auto).

Watauga Lake is one of the most picturesque in the entire Tennessee Valley. The visitors' building has a lounge, a handsome TVA exhibit, and rest rooms in the rear. An attendant is on duty every day from 9 a.m. to 5 p.m.

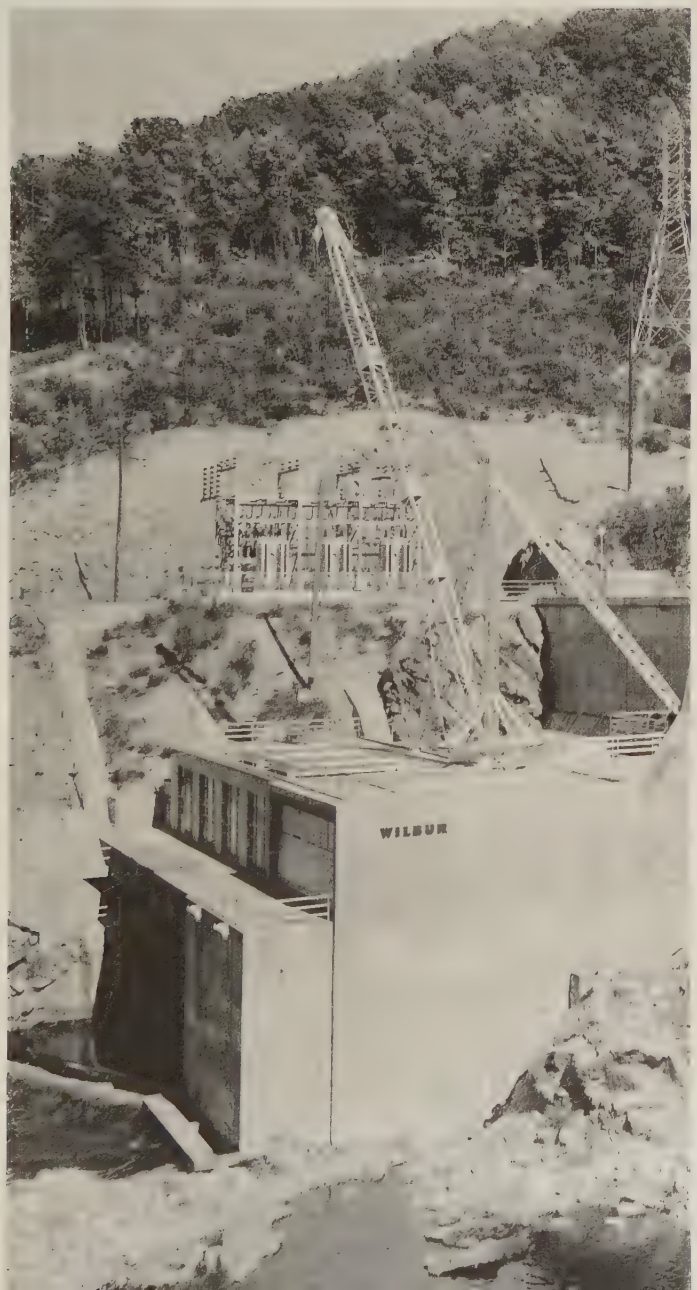


The old dam (*left*) was bought for less than one-half million dollars. With another $2,000,000 TVA raised the dam, installed spillway gates, added another generator, and remodeled the powerhouse.

WILBUR

length	375 ft.
maximum height	77 ft.
acquired by TVA	june 29, 1945
remodeling completed	july 19, 1950
generating capacity	10,700 kw
cost	$2,500,000

To unify its operations in the valley, TVA bought several existing dams, of which Wilbur on the Watauga River is one. As at Great Falls Dam (not shown in this book) and at Hales Bar, considerable remodeling was necessary at Wilbur before its full potential could be realized. This involved raising the dam's height, increasing its generating facilities, and removing silt from behind the dam.



Simple or complex, TVA bridges are designed with clarity and forthrightness. The one above is on U.S. 421, across the South Holston River. The small concrete arch bridge on the opposite page is in the town of Norris, built in 1933.

Nonpower Projects

CHAPTER V

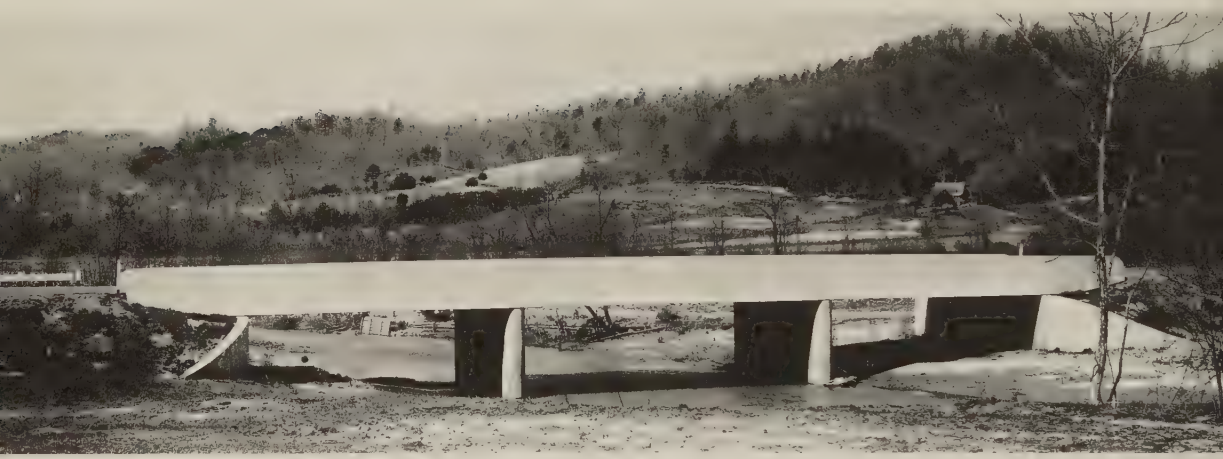
The dams and steam plants represent, of course, the major achievement of TVA's construction program, but they do not represent the entire work by any means. The construction and operation of these facilities necessitated a large amount of related planning and engineering. The impoundment of millions of acre-feet of water was to change the face of the valley. Many old highways and roads were going under water; so were dozens of bridges and miles of railroads and telegraph and telephone lines; even cemeteries were beneath the anticipated high-water line. All of these became the responsibility of TVA. In some cases, entirely new roads had to be built into remote construction areas, and often they, like the Norris Freeway, were to serve as permanent roads after projects were completed.

Additional facilities were necessary at Muscle Shoals for the most efficient operation and development of the chemical works there, and TVA had to think also about its own permanent quarters from which to operate after the job of building was over.

The same designers and engineers who planned and built the dams and steam plants also applied their efforts to the new roads and bridges. When World War II was over, they built a chemical engineering building at Muscle Shoals to expedite the transition from explosives to fertilizer again. And while construction has been postponed for years, pending action in Washington, plans were drawn up for a permanent TVA headquarters, presumably to be located at Muscle Shoals. Like the great dams and steam plants, these related tasks were ap-

proached by TVA architects and engineers with a high degree of creative energy. The smallest culvert and the highest and longest bridge —each was a challenge and an obligation. This chapter gives a fair sampling of that design work. Of the bridges shown, many have been singled out by critics from time to time as representing the best in American bridge design. Four of them were cited by Elizabeth Mock in her book *The Architecture of Bridges.*[1]

[1]Published by the Museum of Modern Art (New York, 1949).



These two small bridges on the Norris Freeway are typical of TVA's early work (1933–34). Of Bull Run Creek Bridge (*above*) Elizabeth Mock says, "Through the flat planes of the piers and beams the bridge becomes a geometric abstraction of its structural idea" (*The Architecture of Bridges*).

What might have been an ordinary truss bridge was given elegance by the reverse arch. Location: Tennessee State Highway 33, across Norris Lake (Clinch River); built, 1933–34.

The essence of this bridge, which spans the diverted North Chickamauga Creek at Chickamauga Dam (1940), is immediately apparent: a continuous steel girder resting on abutments and two concrete piers. Vertical stiffeners are perfectly modulated with the abutments, piers, and lamp posts.

The steel girder bridge above was built across Chickamauga Dam in 1953–54 by the State of Tennessee from TVA plans. The bridge over Soddy Creek (*below*), near Chickamauga, was part of TVA's highway relocation work.

This bridge across the Little Tennessee, about a mile below Fontana Dam, serves as the main access to the dam and to Fontana Village. Built almost entirely of salvaged steel girders, beams, stringers, and bracing from the dam's construction trestle, it was given the American Institute of Steel Construction's national award in 1945 for its striking beauty and simplicity. Note the slight arch in the bridge, best seen in the end view (*bottom*).

The delicate refinement of this bridge across the Nantahala River (Fontana project), near Bryson City, North Carolina, belies its actual size. It is more than twice the length of a football field (727 ft.), and the distance between piers is 228 ft. The piers are about 125 ft. high, or about as high as a ten-story building. This was another of TVA's bridges cited by Elizabeth Mock in *The Architecture of Bridges.*

116 Highway relocations in the Boone reservoir necessitated three new moderately large bridges: two over the South Holston and one over the Watauga River. Since the profiles of the crossings were similar, TVA engineers worked out an over-all scheme for the design and construction of the three bridges. Except for length and height, they are alike in every detail: Rainbow Bridge (*above*) and Devault Bridge (*acrosspage, middle* and *top*), across the South Holston; Pickens Bridge (*bottom, both pages*), across the Watauga.

Rolling the steel girders into place eliminated the need for scaffolding. The cable truss (*above*) kept the Devault girders from deflecting while being rolled from pier to pier.

Backwater from Hiwassee Dam necessitated considerable redevelopment and planning in Murphy, North Carolina. This footbridge, leading to the town's new fair grounds, was part of the planning program. It combines the traditional and graceful arch form with modern steel construction in a most pleasing way.

CHEMICAL ENGINEERING BUILDING

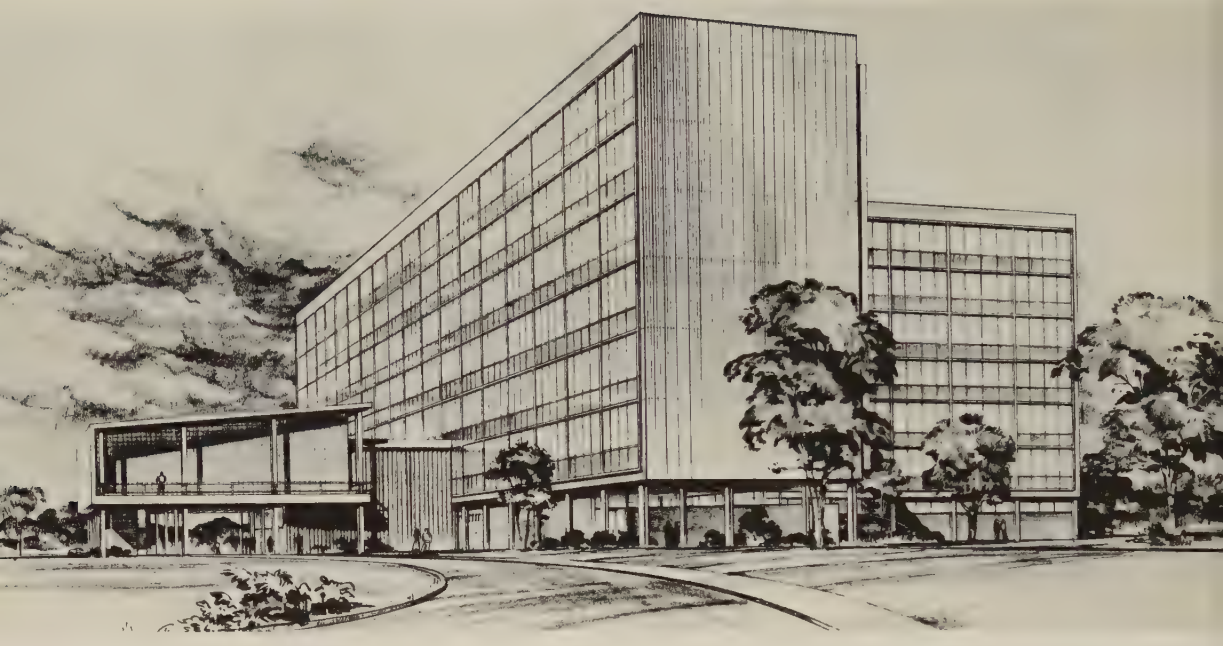
The wartime activities of the Office of Chemical Engineering of TVA became so enlarged that, in 1944, plans were made for the addition of a new research and administrative center near the phosphate and nitrate plants at Muscle Shoals. It was to be a front office, as it were, for the huge chemical complex, which had been converted from the man-

ufacture of fertilizer to that of explosives. With space for research laboratories, offices, an assembly room, a library, and exhibits, it was to become the Chemical Engineering department's nerve center for research and information.

After TVA's preliminary wartime studies, the project was turned over to the New York firm of architects Fellheimer and Wagner for the finished drawings. However, it was not until 1947 that construction got under way, for many materials—especially steel—were as scarce immediately after the war as during the war. The project was completed in 1950.

The main building was constructed of reinforced concrete, faced on the outside with brick and glass, and decorated inside with tile, wood, aluminum, and glass—with terrazzo floors. The attractive assembly room entrance (*below*) is on the mezzanine level of the lobby.

The main gate to the experimental production plants (*above*) consists of a series of time-card aisles covered by a shed of aluminum and glass, supported by handsome rigid steel bents. Hundreds of workers and visitors pass through the gate daily.



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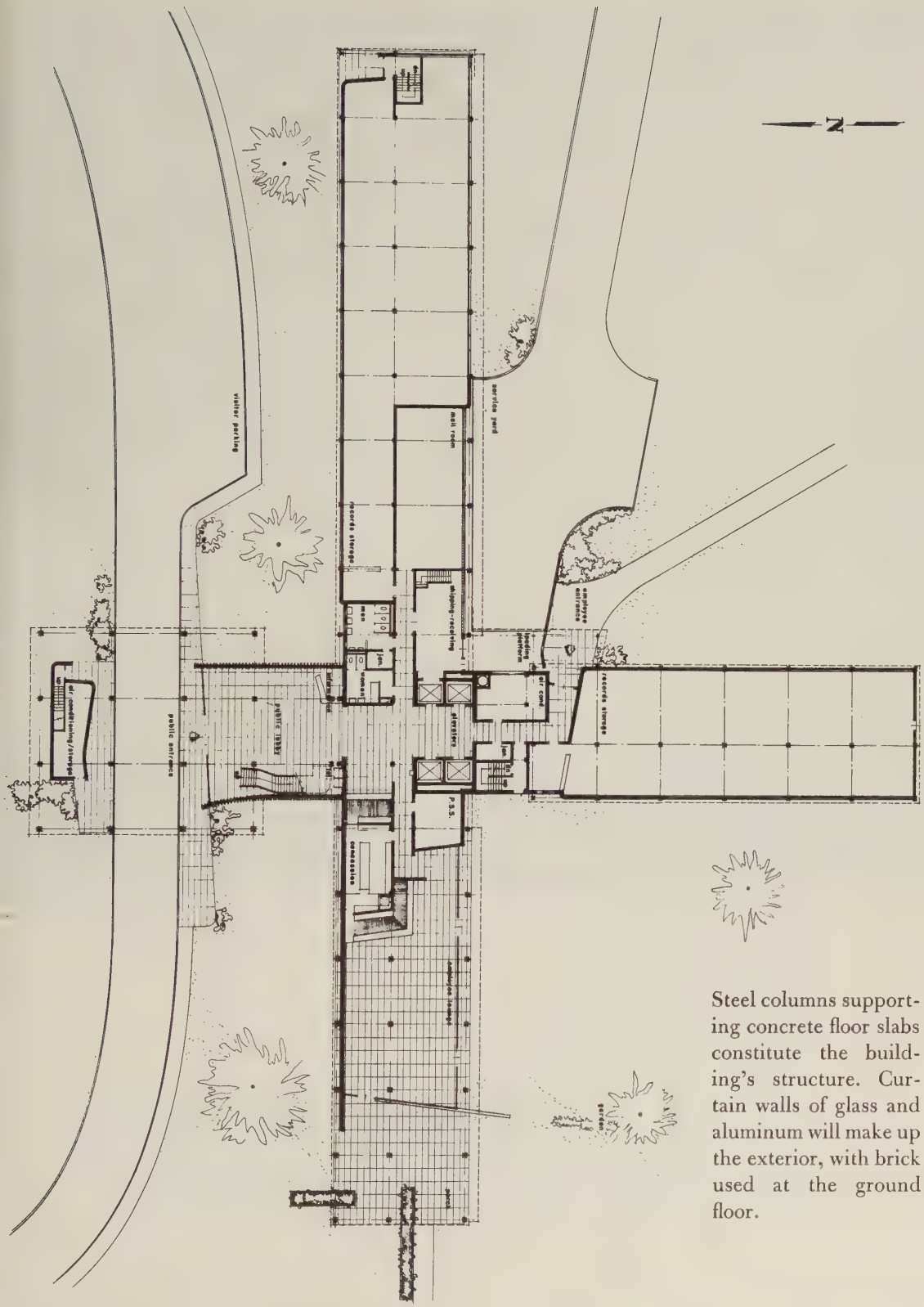
PROPOSED OFFICE BUILDING

When Congress passed the Tennessee Valley Authority Act in 1933, it instructed the organization eventually to maintain its principal offices in the Muscle Shoals area. This is a fairly central location for the direction of TVA's operations (though Knoxville or Chattanooga would serve just as well). Because the largest part of TVA's construction work was in the upper end of the valley, Knoxville early became the unofficial headquarters. No single headquarters building was ever established in Knoxville, however, and TVA offices are still spread all over town, twenty-five years after the act was passed. Work on the proposed building has never been scheduled nor money appropriated. Tennessee is naturally reluctant to see TVA remove its offices to Alabama, and such a move does appear unlikely any time soon. Wherever the permanent headquarters is finally located, TVA's building program will always seem incomplete until this handsome structure is executed.



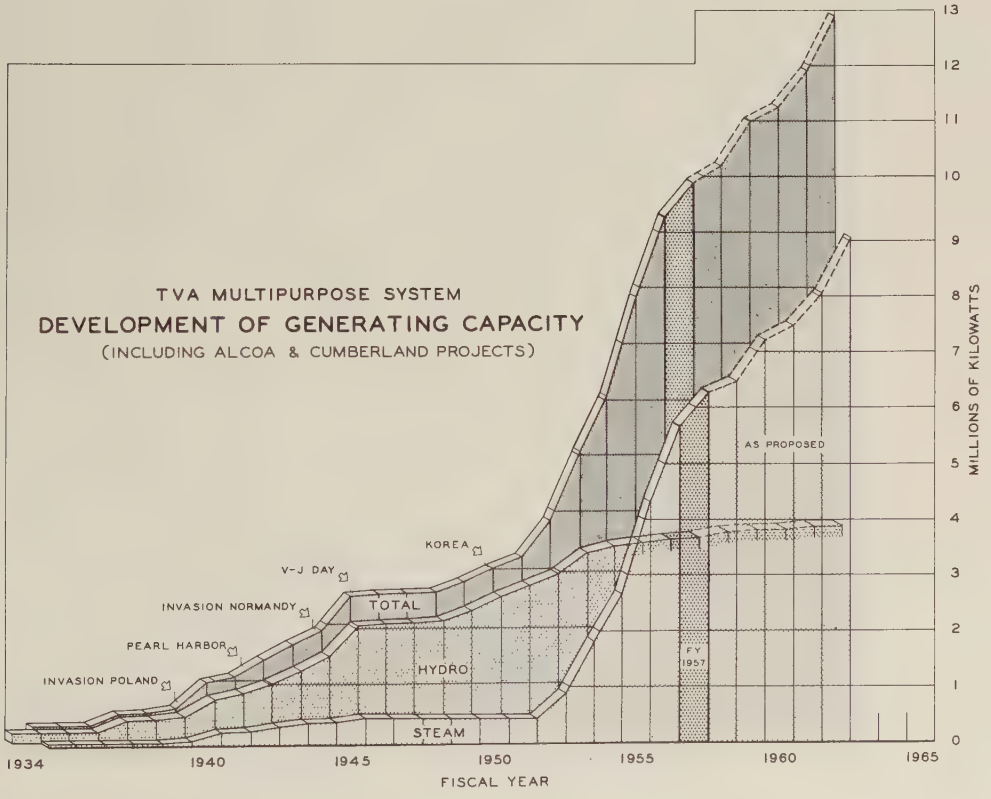
Steel columns supporting concrete floor slabs constitute the building's structure. Curtain walls of glass and aluminum will make up the exterior, with brick used at the ground floor.

One steam plant like Johnsonville can produce more power than the combined peak production of Hiwassee, Norris, Fontana, Douglas, and Cherokee dams.

Steam Plants

CHAPTER VI

One of the first principles of economics is that an abundant supply of a necessary commodity at a low cost leads to an immense consumer demand. So it was with TVA electric power. When TVA began building dams, back in 1933, few could foresee the day when the valley economy would require all of the power that the Tennessee was slated to produce. Yet, by the time of Pearl Harbor, in 1941, the valley was faced with an anticipated shortage, despite the fact that its power capacity had been doubled in only eight years. Shortly after our entry into World War II the valley was selected for the location of the government's first atomic energy plant, Oak Ridge. While geography played a part in the choice of this location, the primary factor was

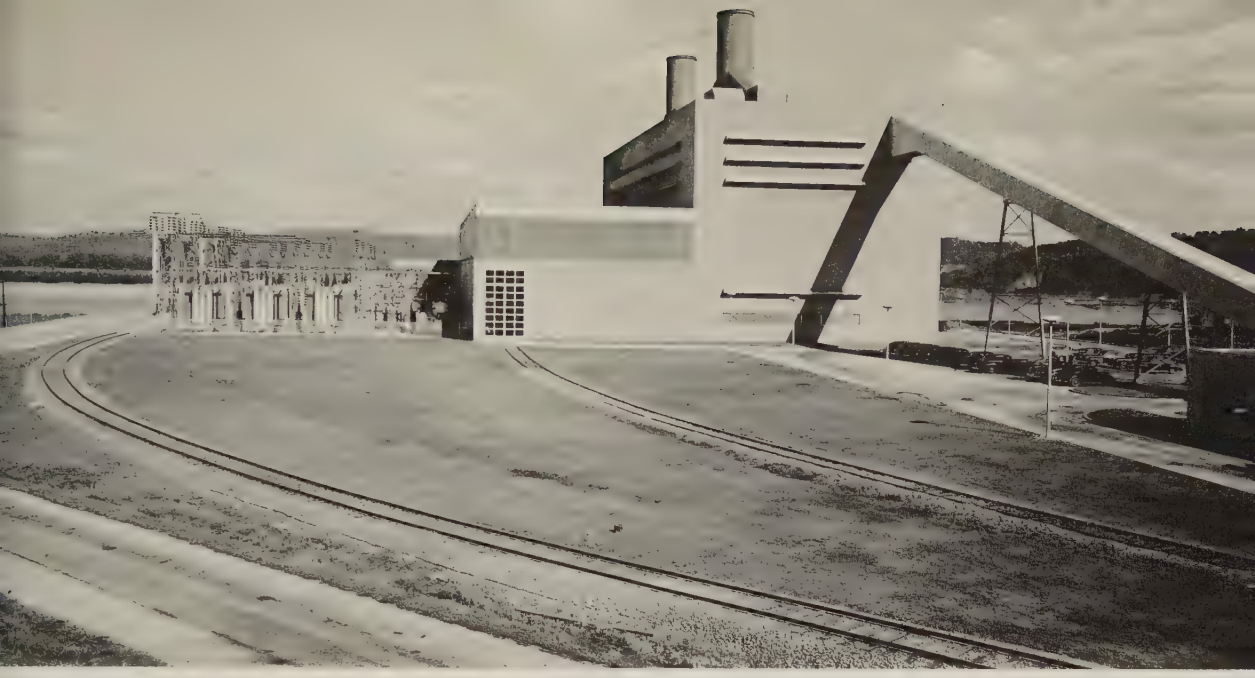


TVA's proven ability to produce power in large quantities quickly and economically. In order to meet this unprecedented need, TVA was forced to consider a source of energy other than hydroelectric generators. Already in need of a source of steady production to offset the seasonal fluctuations in output of the river system, TVA decided to build a steam generating plant, Watts Bar Steam Plant (*acrosspage*). This, plus the several dams nearing completion, again nearly doubled TVA's power capacity by the end of the war, about one-fifth of it generated from coal and steam.

After the war, the residential, rural, and industrial demand for TVA power did not slacken; instead, it increased. Congress provided funds for still more steam capacity in the form of the Johnsonville Steam Plant, which was begun in 1949. The following year brought the beginning of the Korean War, which turned out to be the largest single impetus ever felt by TVA. With global atomic warfare now a distinct and ghastly possibility, the government's Oak Ridge operations were greatly expanded, and the Atomic Energy Commission ordered another "Oak Ridge" to be built near Paducah, Kentucky, just at the edge of TVA's power system. Together these two plants were to require double the power consumed by the entire city of New York—twice as much as the entire river system could produce.

Once again it was clear that TVA's generating capacity had to be increased further and that the power had to come from steam plants. TVA responded quickly to the call, and by the middle of 1953 construction had begun on the eighth of these steam plants. Though threats of atomic war subsided, homes, farms, and industries continued to expand their use of electricity, and by 1956 it was found necessary to begin expansion of three of these plants.

Today, twenty-five years after the birth of TVA, the power generating capacity of the valley region is over ten million kilowatts, more than twelve times the 1933 capacity. But despite this phenomenal achievement, the power service area is facing another shortage in the near future unless provision is made for financing the construction of new generating capacity. Half of TVA's output goes directly into government nuclear plants, and the civilian economy, increasing its consumption by 10 per cent a year, will soon be using all TVA's remaining capacity. Memphis, formerly served by TVA power, is today building its own steam plant to obtain electricity that was to have been furnished, first, by TVA's proposed Fulton Steam Plant and, second, by the costly and controversial Dixon-Yates plant.



WATTS BAR

127

construction started	: august 8, 1940
first unit on line	: february 15, 1942
last unit on line	: april 8, 1945
number and size of units	: 4—66,667 kw
total capability	: 266,668 kw
cost	: $19,800,000

The first and smallest of TVA-built steam plants, Watts Bar was begun a year later than Watts Bar Dam, which is less than a mile away (see p. 40). It was producing power, however, only four days later than the hydroelectric generators at the dam. In the photograph above we can trace the process of producing electricity from coal. From right to left, we see (1) the conveyor, which brings crushed coal up to (2) the pulverizers, whence it is blown into (3) the boilers (under smokestacks), where water is turned into steam to drive (4) the turbines (low wing), which drive the generators, producing electric power that is transmitted from (5) the switchyard.

Since large coal bunkers are located along most of the wall area, no windows were installed in the boiler wing. Instead, the designers specified artificial lighting throughout, with air brought in through slits under the long horizontal hoods. In the generator wing, coal dust is no problem, thus permitting the use of a large course of glass blocks to provide plenty of natural light. The most striking thing about this and subsequent TVA steam plants is the absence of compromise. Massive components appear massive; no attempt was made to break them down into elements nearer the human scale. The result is an imposing sculptural form expressive of modern technology.

At the turn of the century, seven pounds of coal were required to produce one kilowatt-hour of electricity. Watts Bar requires just under one pound, but TVA's latest plants use only three-fourths of a pound per kilowatt-hour. Hence, Watts Bar is operated today only when the more efficient plants cannot meet consumer needs.

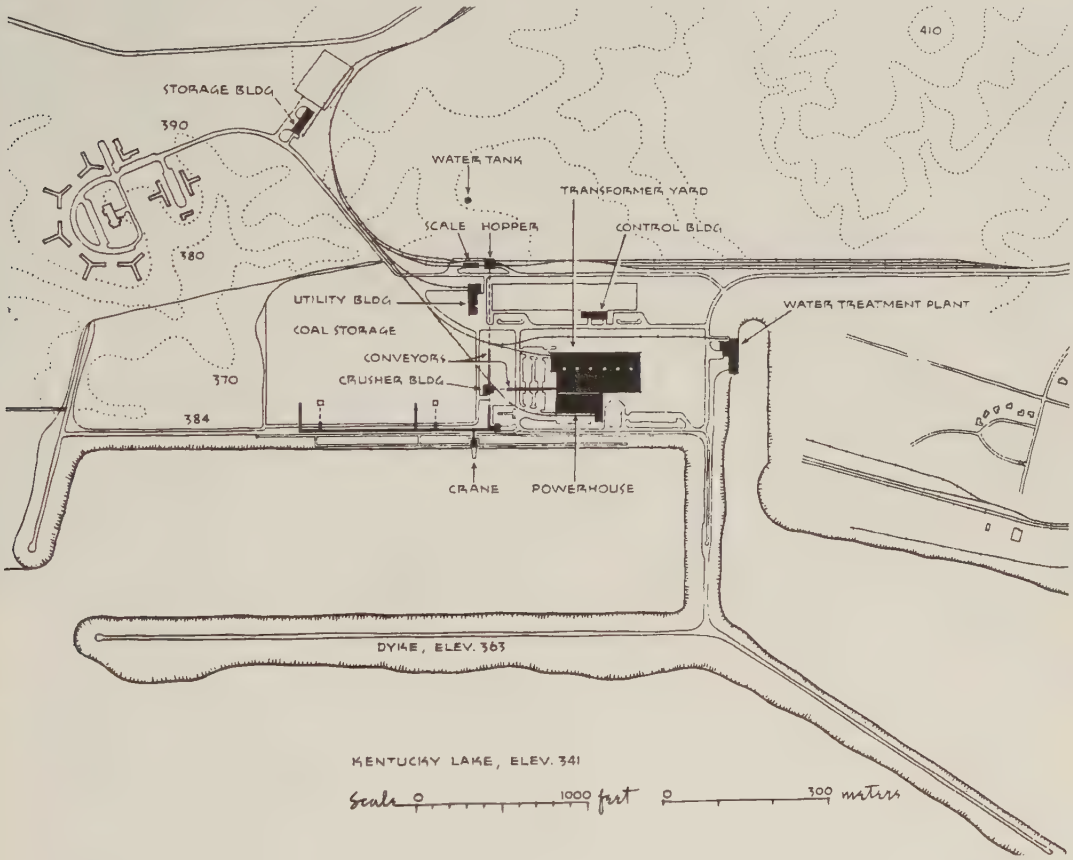
JOHNSONVILLE

130

construction started	: may 12, 1949
first unit on line	: october 27, 1951
sixth unit on line	: february 22, 1953
no. and size of initial units	: 6—125,000 kw
initial total capability	: 750,000 kw
cost	: $94,300,000

Located near Waverly, in western Tennessee, where U. S. 70 crosses the Tennessee River, the second of TVA's steam plants differs from Watts Bar in many ways. First of all, it is nearly three times as large as the earlier plant (in July, 1956, construction on four more units at Johnsonville began, but cost and capability totals here do not include these new units). Because of this great difference in size, it was necessary at Johnsonville to abandon the single-structure concept and deal with each of the plant's components separately. Thus, though they

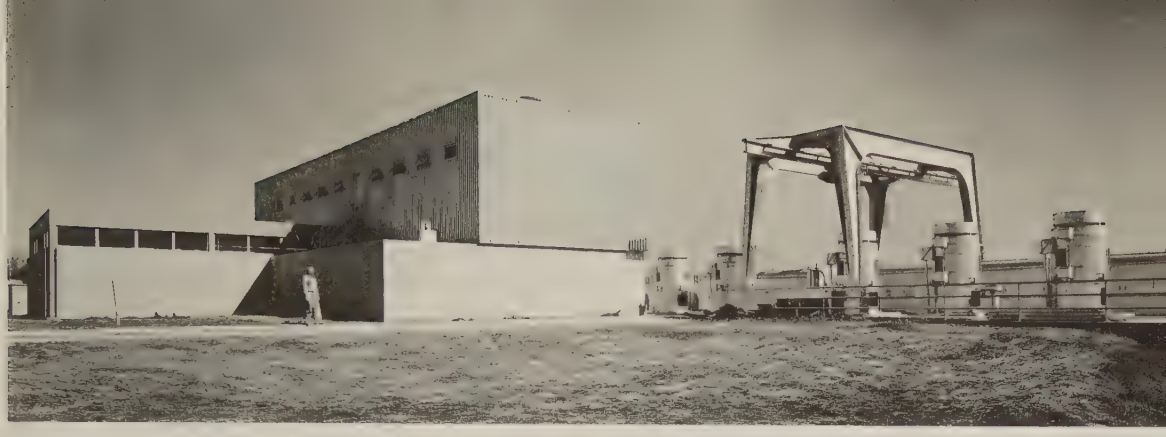
are closely related to and often continuous with the huge boiler wing, the generator room, office wing, shops and laboratories, and control offices are distinctly expressed. This is apparent not only in scale but also in the materials used. The boiler wing, for example, the plant's largest mass, employs aluminum panels to cover the vast expanses of its exterior walls, whereas brick covers the walls of the generator room, the office wing, and the shops and laboratories. The brick serves visually to anchor the lighter but much larger aluminum mass to the



Dikes were built out from the shore to create a small harbor for coal barges and to control the intake and discharge of river water. Aside from coal transportation, the river is very important to the functioning of the plant. A large supply of cool running water is necessary for steam condensation.

ground, a design scheme characteristic of Johnsonville's other completely separate structures such as the water treatment plant and the conveyor control and crusher building (*above*). In fact, this fundamental scheme was used in virtually all of TVA's subsequent plants.

Looking down from the top of the plant, we see the whole coal-handling complex. The hub of the operations is the conveyor control and crusher building, which receives coal from either the crane at left, the storage yard above, or the rail siding at right (not shown). In this building the coal is crushed to a maximum size of 1¼ inches; then it is conveyed up to the bunkers and thence to pulverizers before being blown into the boilers. What looks like a freight train parallel to the

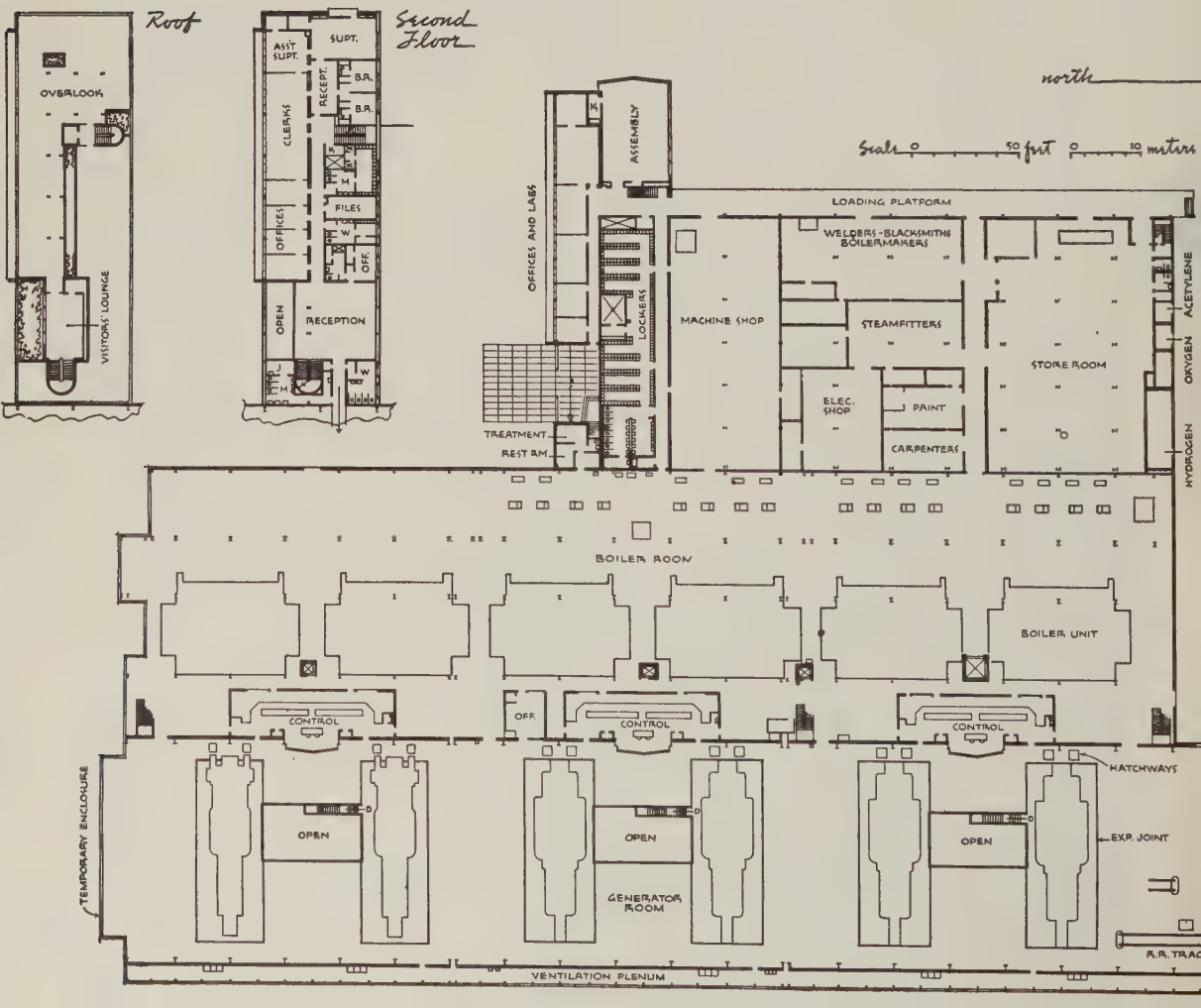


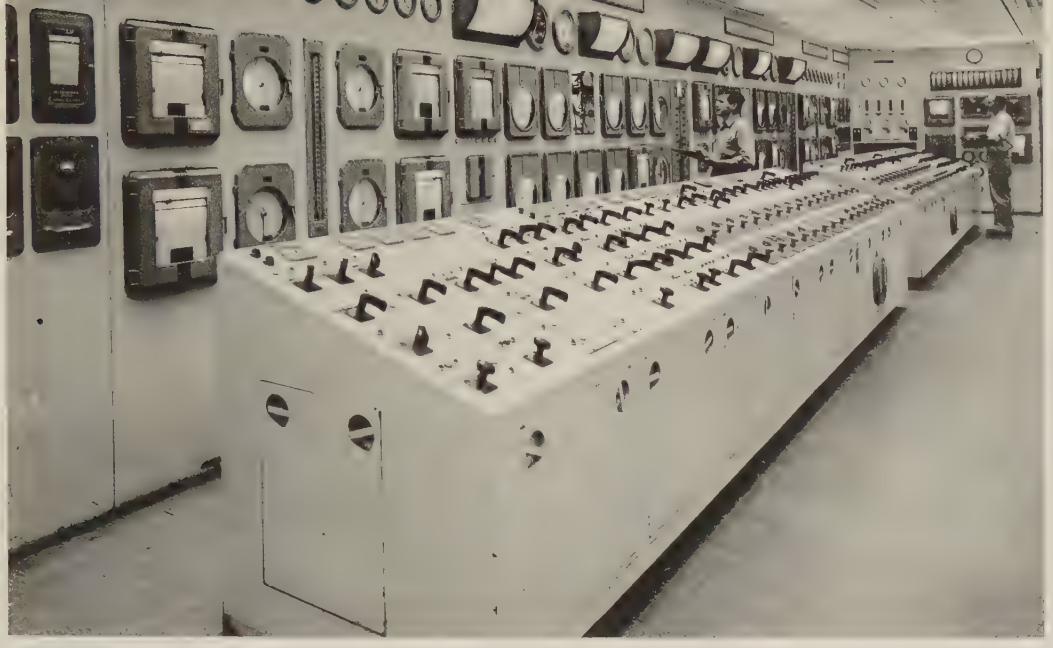
river bank is actually an enclosed conveyor that carries coal both to the yard and to the crusher.

Handling coal is at best a very dirty job, but TVA architects and engineers have learned to deal with it. Where they were absolutely unable to control the dust—in the conveyors—they specified a dark maroon paint. Where the dust was chronic but not acute, they specified smooth aluminum paneling.

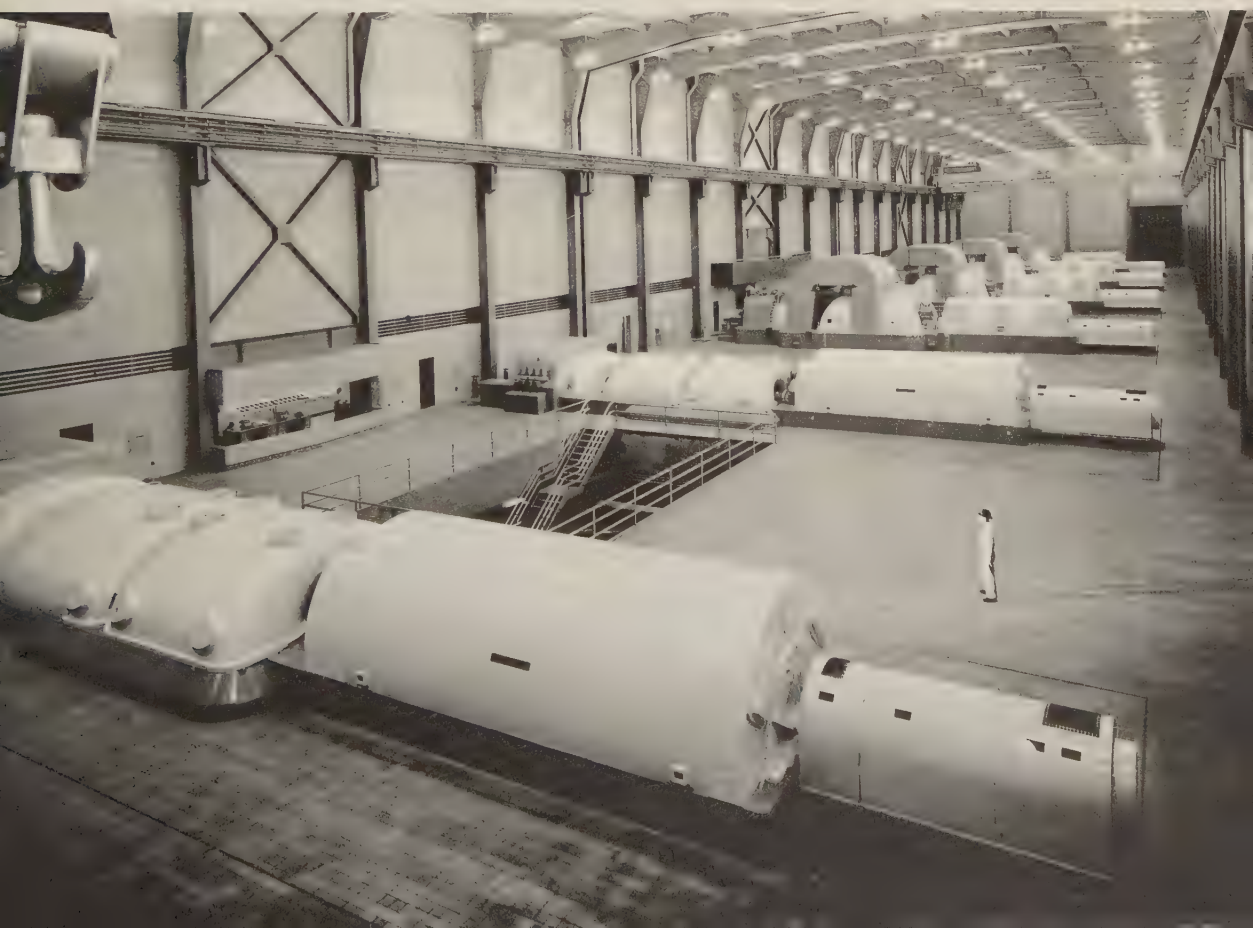
The water treatment plant (*above*) is consistent with the rest of Johnsonville in its structure and use of materials: steel frame; brick siding at the ground level; aluminum panels above ground level.

The proper height of the stacks could be determined exactly only after the plant was in operation; they are here being raised 100 ft. The boiler room plan (*below*) represents the tallest wing of the building, and the boilers themselves are 138 ft. high, equivalent to a ten-story building. Each unit is capable of burning 54 tons of coal per hour.

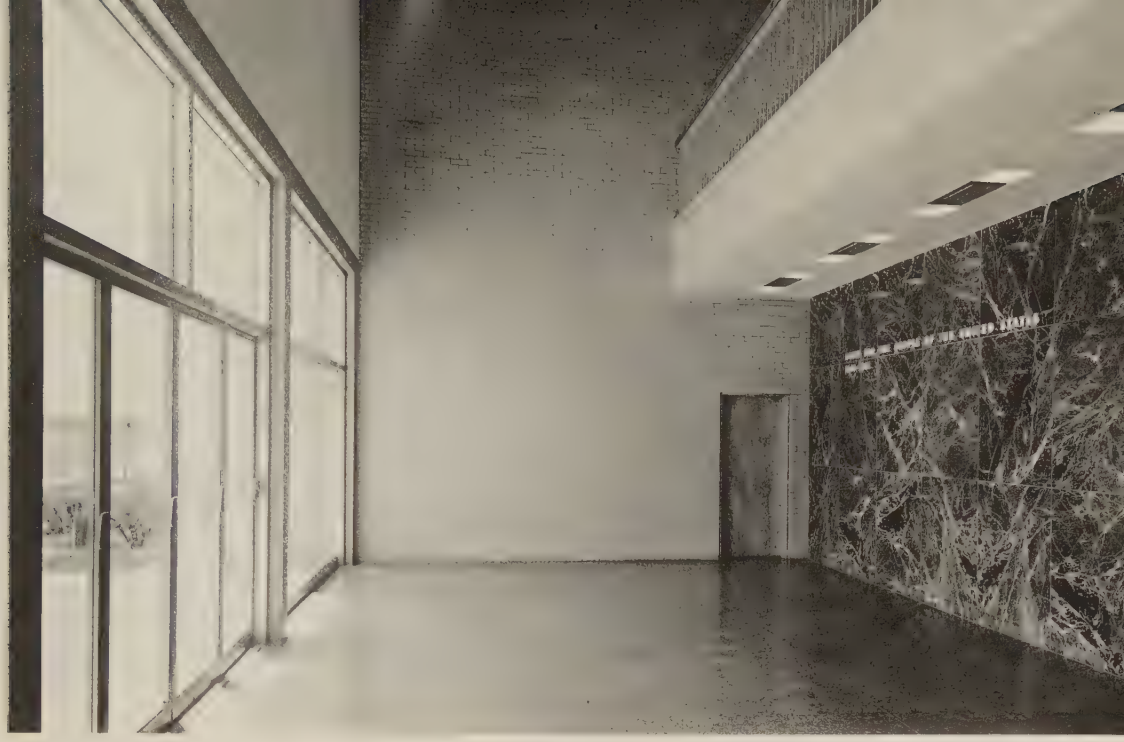




The well-designed control room above is one of three at Johnsonville. A visitors' balcony is directly over the center one (*below*). Heavy equipment can be picked up by the mobile ceiling crane at the far end of the room (*below*) and carried to the large service door, where it can be placed on a railway car. The photograph at left shows a railway car almost entirely inside the door.



Above is the main entrance and office wing. At right is a view of the visitors' deck above the offices. Below is the loading area for the shops.



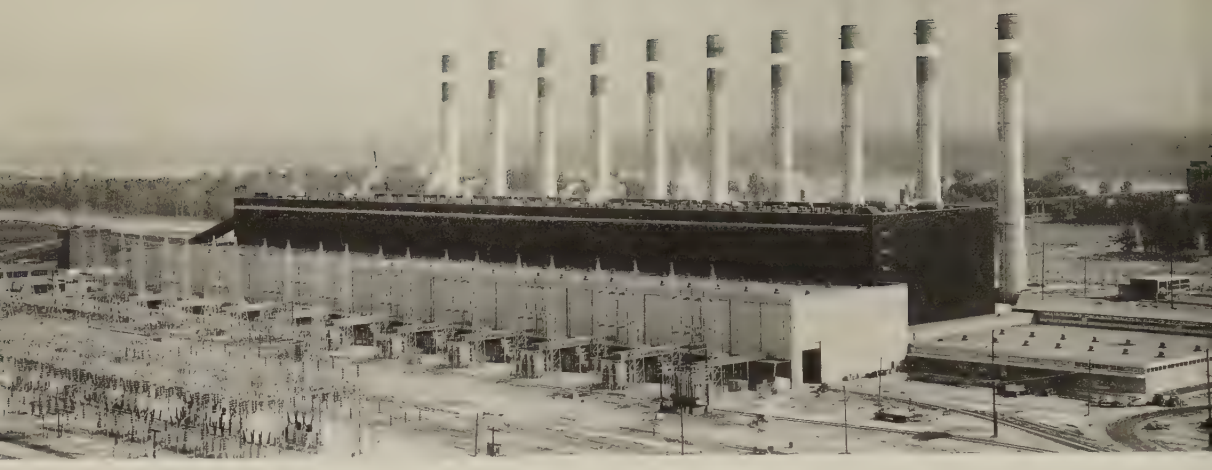
Ordinarily, steam plants are not considered tourist attractions, but TVA discovered that people are quite interested in them. Limited visitors' facilities were provided at Watts Bar, but at Johnsonville the visitor walks into the very attractive lobby above (here unfurnished). In the second floor reception room he will find two beautiful murals depicting the construction and operation of the plant and a panorama of the Tennessee Valley.

WIDOWS CREEK

construction started	: march 29, 1950
first unit on line	: july 1, 1952
last unit on line	: july 17, 1954
number and size of units	: 6—125,000 kw
total capability	: 750,000 kw
cost	: $93,000,000

Located in northeastern Alabama, on the Guntersville reservoir, Widows Creek Steam Plant was designed and built along lines closely similar to those of Johnsonville, before the latter began its expansion in 1956. They have the same rated capability, the same number of units; even the structure is the same. Widows Creek is now being enlarged by the addition of a single unit capable of producing 500,000 kilowatts—the largest single unit in the world. The photograph above shows it as it looked in 1953, a year before initial completion.

The two pictures on this page might be mistaken for Johnsonville except that the coal sampler at the top of the conveyor seems to be missing. Actually it is inside the building. The conveyor control and crusher building (*below*) is an almost exact duplicate of the same structure at Johnsonville.



SHAWNEE

140

construction started	: january 6, 1951
first unit on line	: april 9, 1953
last unit on line	: october 12, 1956
number and size of units	: 10—150,000 kw
total capability	: 1,500,000 kw
cost	: $216,000,000

In 1951, TVA and a combine of private power companies known as Electric Energy, Inc., began construction of two steam power plants to supply the Atomic Energy Commission's new gaseous diffusion plant at Paducah, Kentucky. TVA's plant, Shawnee, was going up on the south bank of the Ohio River, and EEInc's was going up on the north. Because EEInc's plant was to be built with private funds (guaranteed by the government), was to be built by private contractors, and was to have no "frills" like the TVA plant, members of EEInc issued a challenge to TVA: Which organization could supply the Atomic Energy Commission with power sooner and at the lower rate? EEInc's Joppa plant, as it was called, was to have most of its equipment out in the open, unlike TVA's, which was to be enclosed.

Two years later, on April 9, 1953, despite labor difficulties about equal to those encountered by EEInc, TVA was producing power from its first unit. Its second unit was producing on June 21. Several weeks later, EEInc's first unit began to produce, EEInc having already lost the speed contest. In 1954, the costs per kilowatt of capability for both plants were estimated at $188 for the Joppa plant and $145 for the Shawnee plant.

Aside from the economic ramifications of this contest (the taxpayer receives both bills through the Atomic Energy Commission), the result is high testimony to the skill and efficiency of TVA's design and construction team, for they produced one of the handsomest and largest industrial structures in the world.

The well-designed chlorination building at Shawnee cost no more than one less well designed. Most of the cost is for materials, equipment, and labor; little goes for design.

KINGSTON

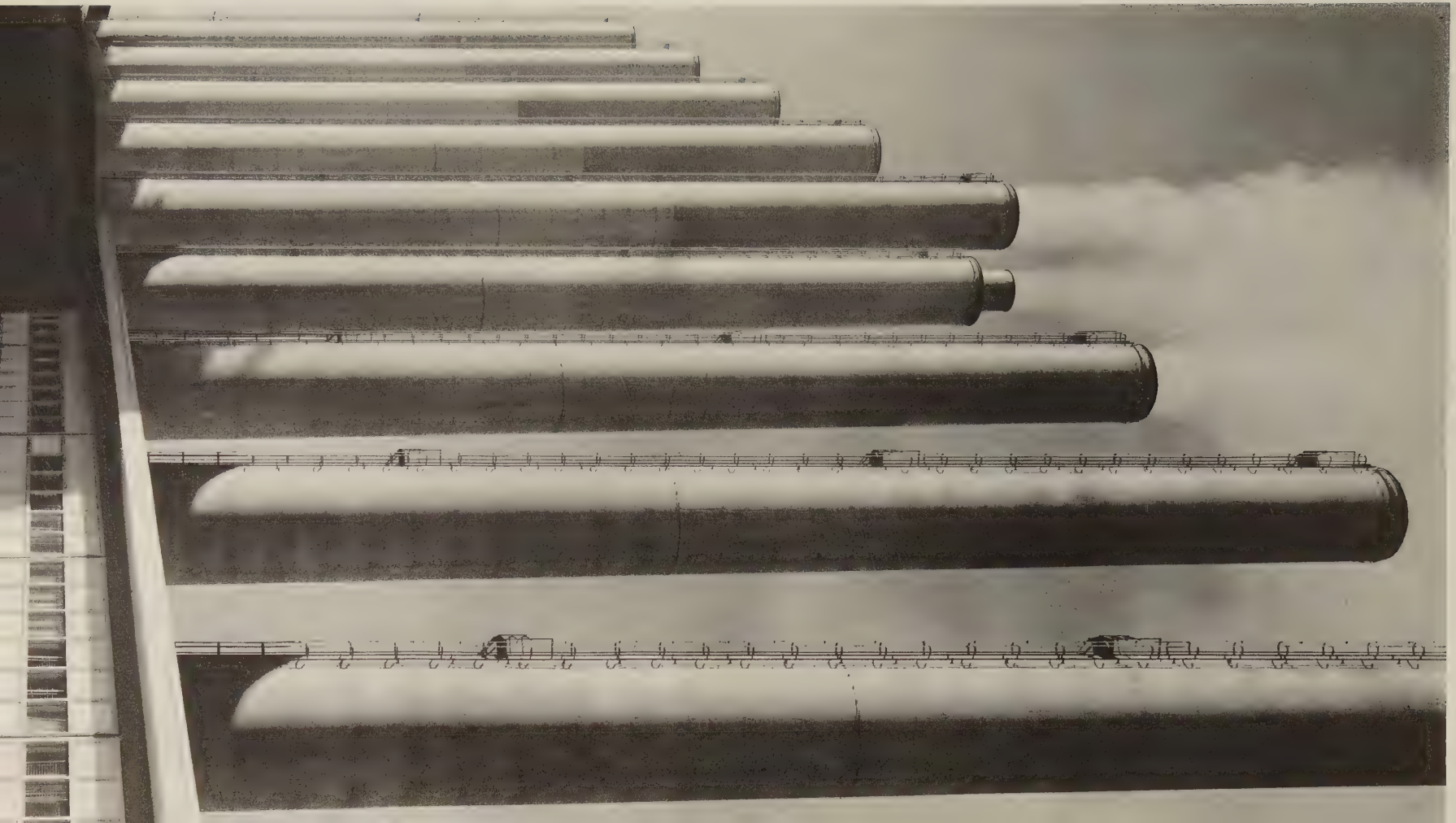
construction started	: april 30, 1951
first unit on line	: february 8, 1954
last unit on line	: december 2, 1955
number and size of units	: 4—150,000 kw
	5—200,000 kw
total capability	: 1,600,000 kw
cost	: $199,500,000

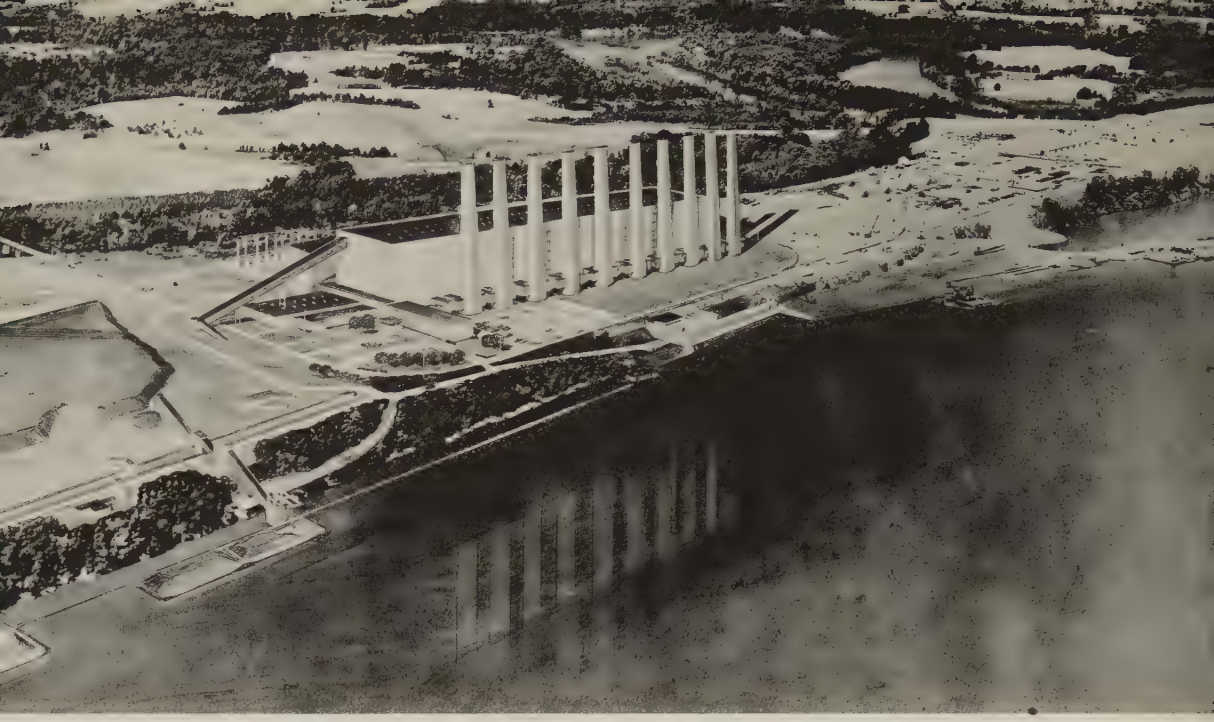
Situated on Watts Bar reservoir near the confluence of the Clinch and Tennessee rivers, Kingston is the world's largest steam electric plant, topping Shawnee by 100,000 kilowatts. Like Johnsonville and Widows Creek, Kingston and Shawnee were designed along very similar lines, and they both differ noticeably from the previous two plants. The most obvious difference is in the smokestacks, which at Kingston and Shawnee rise from the ground level and are apart from the powerhouse. It is in the smokestacks, also, that the difference between King-

ston and Shawnee is most apparent. Shawnee has ten of equal height; Kingston, despite its greater power capability, has nine of two different heights.

When Kingston was initially planned, it was scheduled to have nine 150,000 kilowatt generators, but after the first four units were under construction, it was decided to use more efficient units of 200,000 kilowatts for the last five. Because of this, and because the first four smokestacks were not high enough, it was also decided to raise the remaining stacks to 300 feet, 50 feet higher than the others. The result is less harmonious than Shawnee's even row of stacks, but the large cowlings at the powerhouse roof help Kingston to avoid the box-like appearance of Shawnee. Both powerhouses were painted dark maroon, which is beautifully complemented by the yellow-buff brick at ground level. Kingston's principal purpose is to provide power for nearby Oak Ridge.

The second floor visitors' lounge at Kingston is one of the most attractive in the TVA system. The first four generator-turbine units are seen below in the foreground; the last five are in the background. The nozzle on the fourth smokestack (*acrosspage*) was an experiment to see if the smoke could be blown high enough to eliminate the necessity of raising the stacks.





COLBERT

construction started	: october 15, 1951
first unit on line	: january 18, 1955
fourth unit on line	: november 4, 1955
number and size of units	: 4—200,000 kw
total capability	: 800,000 kw
cost	: $104,500,000

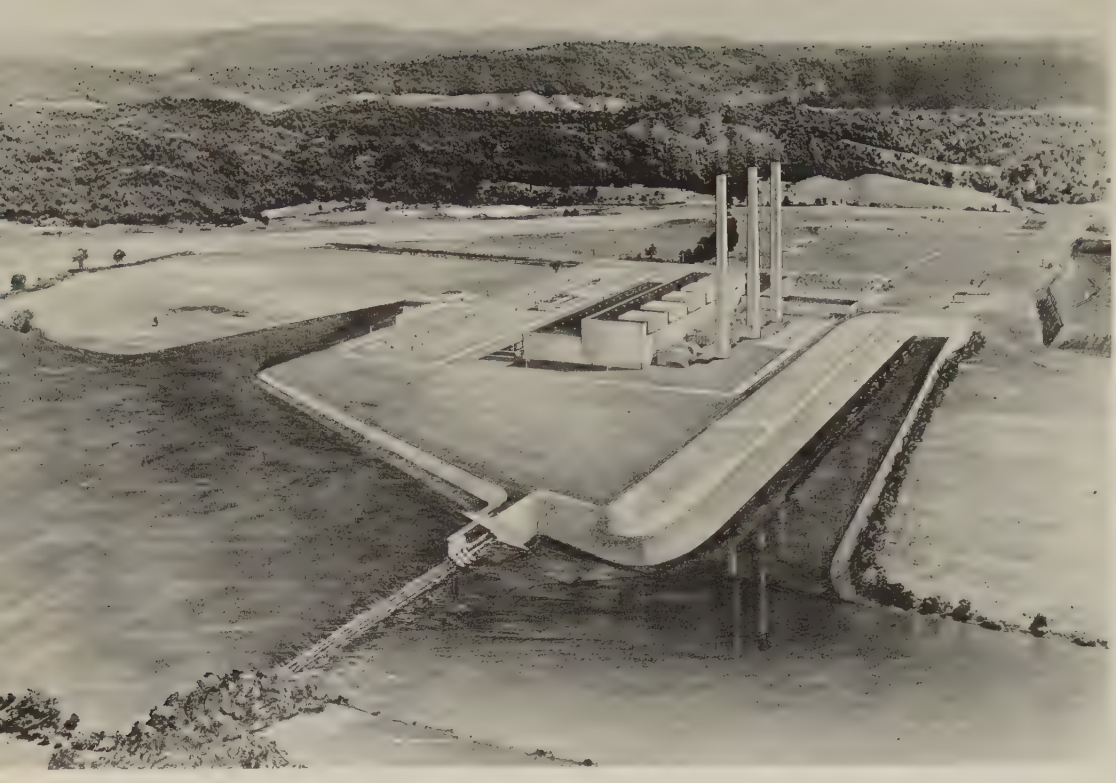
The drawing above, superimposed on an aerial photograph of the Colbert site, shows what the plant will some day look like, when the last of its ten units has been built. To date, however, only four units have been scheduled and built (*acrosspage*). If completed according to the present plans, Colbert would have a total capability of 2,000,000 kilowatts, larger even than Kingston. But it is probable that units of at least 250,000 kilowatts each, like those at Gallatin, would be used for the remaining six, bringing the total capability to 2,300,000 kilowatts,

just 470,000 kilowatts less than the entire capacity of TVA's combined hydroelectric plants.

The 300-foot stacks at Colbert are similar to those at Kingston and Shawnee, but TVA's designers reverted to aluminum panels for the powerhouse covering. Notice the reflection on the wall behind the stacks (*below*). Compare the ground at right with the finished landscape at left. When the power is needed and the money appropriated by Congress, TVA can remove the false end walls and add on the remaining six units as well as finish the water treatment plant in the foreground.

Glass, brick, structural steel, and attractive porcelain-enameled panels make up the exterior of the office wing above. With a backdrop of aluminum sheeting and concrete smokestacks, the contrast is most pleasing. Below is the conveyor control building, which overlooks the coal distribution system from the unloading cranes (*acrosspage*) to the powerhouse conveyor.

Twelve miles downstream from Wilson Dam, Colbert, like most other TVA steam plants, depends on the river for transporting much of the coal it uses. Each of its four units burns about 76 tons of coal per hour, which keeps these unloading cranes busy.



JOHN SEVIER

150

construction started	: october 14, 1952
first unit on line	: july 12, 1955
fourth unit on line	: october 31, 1957
number and size of units	: 4—200,000 kw
total capability	: 800,000 kw
cost	: $115,500,000

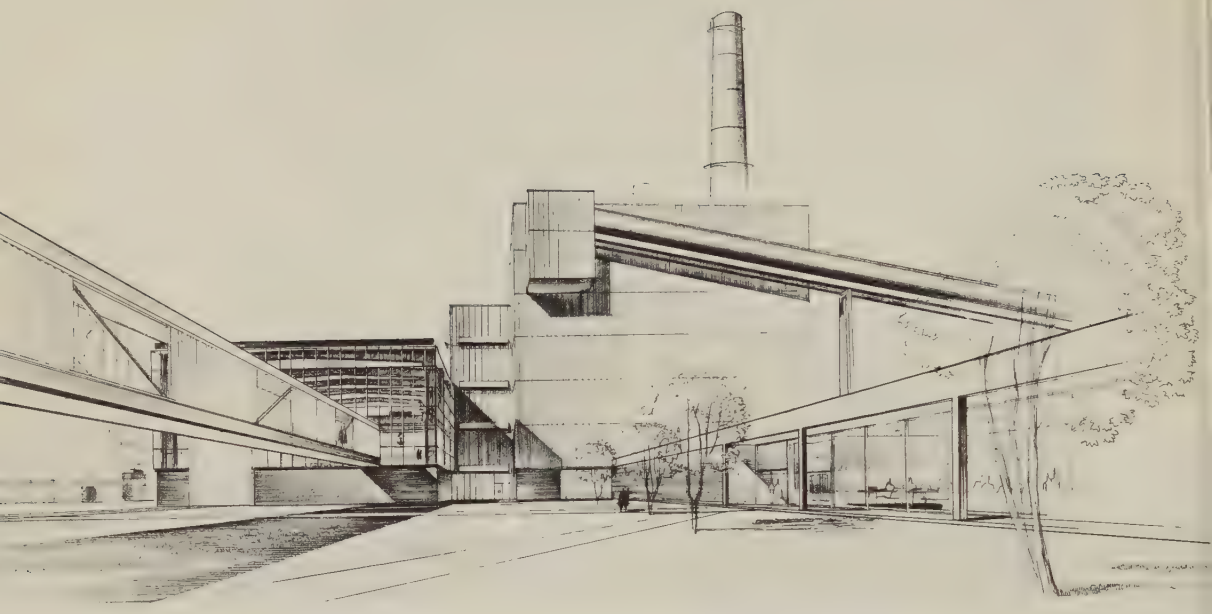
Designed for an ultimate capability of 1,200,000 kilowatts, in six units (drawing *above*), the John Sevier plant was begun with the intention of building only three units for the present. Just as the third unit was placed in operation (*acrosspage*), in 1956, it was decided to install the fourth unit. Aside from the fact that the power was needed in eastern Tennessee, western Virginia, and western North Carolina, it was most economical to build the fourth unit at that time. The two-unit smokestack—for units 3 and 4—was already standing, and the labor force

and construction equipment were on hand for a speedy job. Units 5 and 6 had not been scheduled yet in early 1958, but power consumption is increasing so rapidly in the area that they will have to be scheduled soon.

Because of the plant's location, on upper Cherokee reservoir (Holston River) where the water is not deep, John Sevier is unique among TVA-built plants in that it receives no coal by river barge. All of the coal is brought in by rail, though TVA has made studies for bringing it in by pipeline from Virginia in a mixture of water and coal. Also because of the lack of water depth it was necessary to build a small detention dam across the Holston to insure a constant supply of cooling water for the plant's steam condensers. This water is drawn in at the water treatment plant behind the switchyard (*acrosspage*) and discharged into the channel in front of the smokestacks.

Since all of John Sevier's coal is delivered by rail, the plant does not have the elaborate system of conveyors that a plant like Johnsonville has. Fundamentally, however, they work the same way: the unloaded coal is routed to a central control area (*above*), where it is either crushed and conveyed to the powerhouse or diverted to the storage yard via stocking-out conveyors like those below.

Porcelain-enamel panels were used to cover the office wing at John Sevier, and insulated aluminum panels were used on the powerhouse. Notice the dark colored cowlings at the roof line, which harmonize with the conveyors and the trim of the office wing.



GALLATIN

154

construction started	: may 11, 1953
first unit on line	: november 8, 1956
second unit on line	: june 27, 1957
number and size of units	: 2—250,000 kw
total capability	: 500,000 kw
cost	: $81,500,000

This is TVA's seventh steam plant in seven years. Johnsonville was started in 1949, and Gallatin's second unit was producing in 1956—a construction achievement perhaps surpassing even TVA's dam-building record. Designed as a ten-unit plant, it will be built in stages, like Colbert and John Sevier. By 1957 the first two units had been built, and two more were scheduled for completion in 1959.

In keeping with TVA's progressive spirit, Gallatin represents the latest in thermoelectrical design. No group of engineers and archi-

tects knows more about steam plants now than the men at TVA. With each new plant the staff has sought to incorporate all of the advances gained in the design and construction of the previous plant. Thus, we see several innovations in this plant at Gallatin, Tennessee, near Nashville, on the Cumberland River. Most apparent from the outside is the free use of large sheets of heat-resistant glass in the generator wing (shown in the drawing at left, but not yet installed in the photograph below). This innovation, plus glass walls in the office building and in the elevated corridor connecting the office building with the generator wing, create an altogether different and lighter appearance than that at any of the other plants. Moreover, when the next units are built, it is probable that the generator sizes will be stepped up from 250,000 kilowatts to 275,000 kilowatts.

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